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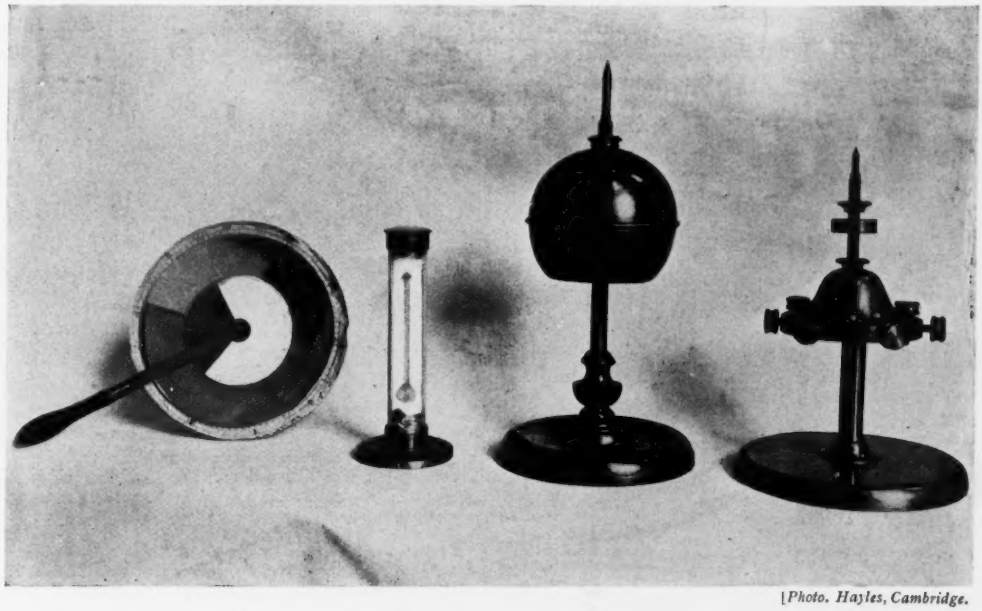
The Cavendish Laboratory and Sir J. J. Thomson, F.R.S.

By ALEXANDER WOOD, B.A. (Cantab.), D.Sc. (Glas.)

THERE is a strange fascination about a Research Laboratory. An element of romance surrounds the attempt to pry into Nature's secrets and discover the principles upon which she works. It is impossible to pass through the rooms with their weird collections of mysterious-looking apparatus, each with its eager manipulator, without having one's curiosity and interest aroused. This feeling is intensified if the rooms are associated with the work of men whose names are known and honoured all over the scientific world. The Cavendish Laboratory, at Cambridge, is no exception to this general rule. There are other laboratories better built and better equipped, but there are none whose associations and traditions appeal to us more strongly. Not that it is an ancient institution. By comparison with the ancient colleges which surround it, it is painfully modern, and yet, in its short existence, it has acquired traditions of which all who are connected with it are proud. We must not entirely lose sight of the ordinary teaching work of the laboratory—that is an important side of its activities—but its fame as an institution has been built up mainly by the professors and students who have carried on original work within its walls. Year by year and month by month the pages of the *Philosophical Transactions of the Royal Society* and the *Philosophical Magazine* bear eloquent testimony at once to the quality and quantity of the contributions of the Cavendish to our knowledge of Physical Science, and if we take into account not only the work done there, but also the work inspired there but carried on elsewhere, we shall be in a position to appreciate the place which the Cavendish occupies in the scientific world.



[*Photo. Hayles, Cambridge.*

1. 2. 3. 4.

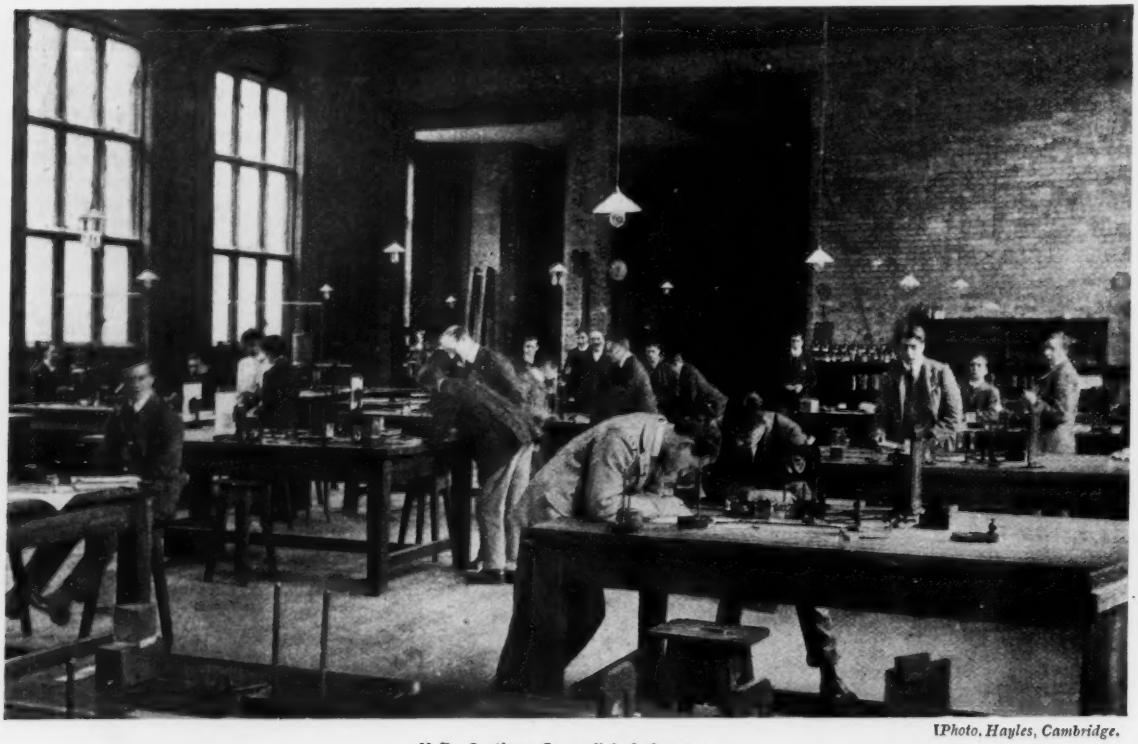
1.—Clerk Maxwell's Colour Top. 2.—Early Florentine Thermometer. 3 & 4.—Clerk Maxwell's Dynamical Tops.

The Laboratory was given to the University and equipped by the seventh Duke of Devonshire, grandfather of the present Duke, and it comes to us as a surprise that it is only thirty years since it was completed. It seems incredible that we are separated by so short an interval from a time when students had no opportunity of engaging in original research and could not even take a course in practical experimental physics. The laboratory was named after the Hon. Henry Cavendish, an ancestor of the donor. He died in 1810, not too late to belong to a time when it was

still possible for one man to traverse the whole field of Physics and Chemistry and do lasting work in every part of the field. He was a pioneer in the chemistry of the atmosphere and of water, while in Physics he was far ahead of his time. Undoubtedly his most important work was contained in his electrical researches. These were not published until long after his death, when his papers were given to Maxwell to edit. The experiment with which his name is principally associated and which appeals most strongly to the popular imagination is the "Cavendish" experiment. In this experiment he used the torsion of a wire to measure the attraction between two metal spheres, and applied his result to "weigh the earth," *i.e.*, to a determination of its mean density and mass. For these quantities he obtained values which agree well with those obtained by later experimenters. He was an eccentric genius and lived in a house on Clapham Common. He had a magnificent library some little distance from his house, and this his friends were allowed to use without any restriction, but he himself never took out a book without making out a careful receipt for it. He led a very lonely life, and had a horror of publicity and public functions. He died at the ripe age of 80, and is supposed to have spoken fewer words in his lifetime than any other man of the same age—the Trappist monks not excepted.

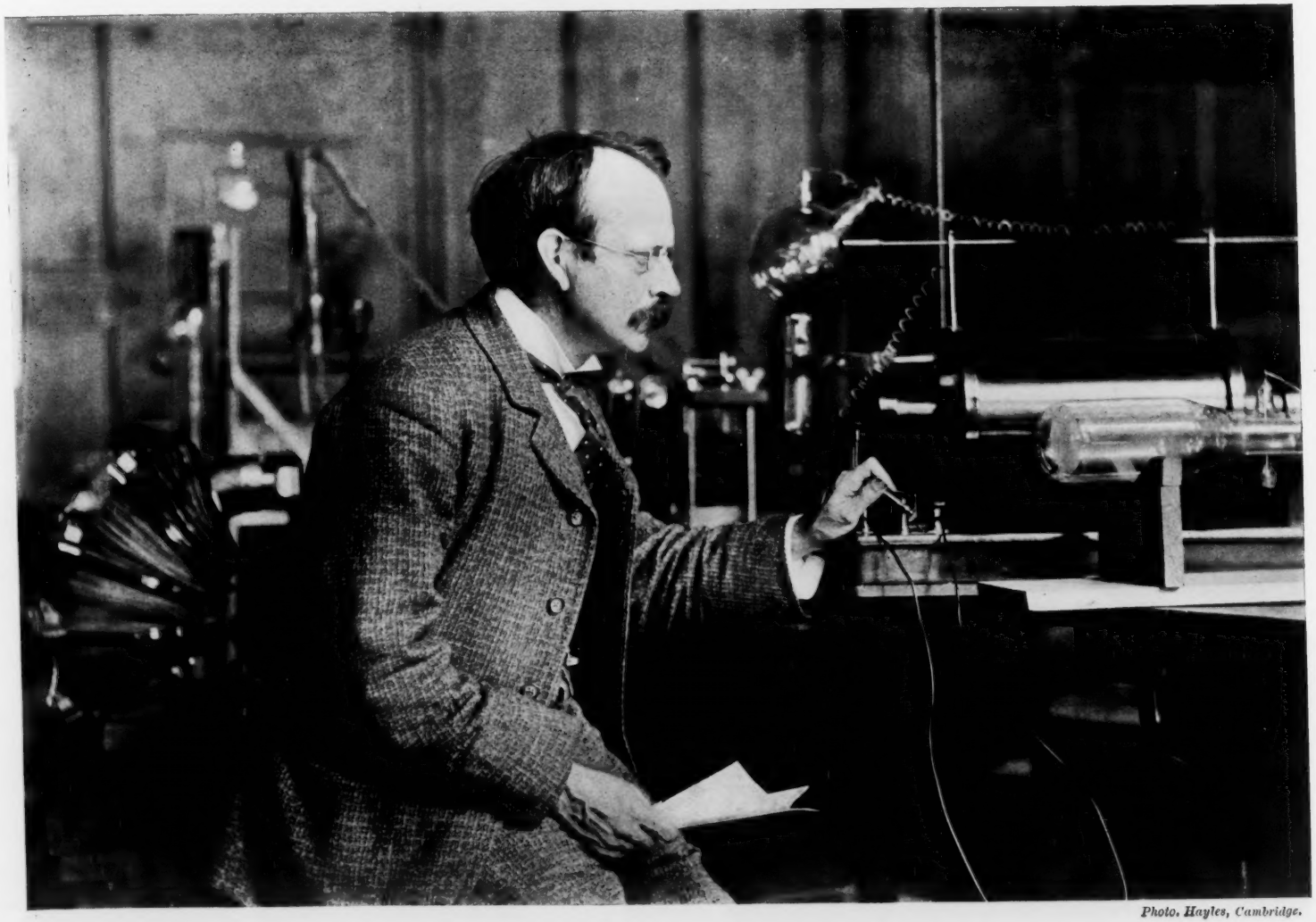
When it became known that Sir William Thomson—as he then was—had refused to become a candidate for the newly-endowed chair of Experimental Physics in Cambridge, the thoughts of those interested turned at once to Clerk Maxwell, and he received many urgent letters pressing the claims of the work upon him and begging him to become a candidate. This he at first refused to do, being unwilling to leave the quiet of the country house to which he had retired. Finally, however, he consented; there was no other candidate, and he was appointed unanimously.

During the tenure of his Professorship, Maxwell's time was largely occupied with the work of supervising the construction and equipment of the laboratory. Every plan was minutely discussed, every piece of apparatus carefully thought out down to the smallest details, and he would accept nothing until he had convinced himself that it was the best possible. Even when this work was completed he had very little time for independent research, owing to the extreme conscientiousness with which he discharged the duty of editing Cavendish's papers—a duty entrusted to him by the Duke of Devonshire. This entailed a great deal of experimental work and was not completed until 1879, within a few months of his death. The contributions of Maxwell to Physics are too well known to require more than a brief mention. His name will always be associated principally with the development of the electromagnetic theory of light. This was the subject upon which he lectured chiefly, his work combining in a wonderful way the mathematical and experimental methods of attack. Like Faraday, he had a mind which loved to search out mechanical analogies to phenomena in other branches of physics, and several of the mechanical models constructed by him are preserved in the laboratory. The subject of colour vision had a strong attraction for him, and by means of ingenious colour-mixing devices he obtained equations showing in what proportions the three primary colours must be mixed in order to produce any given shade. One of these devices—the colour top—is shown in the illustration. It consisted of a top which could be



[*Photo. Hayles, Cambridge.*

M.B. Section, Cavendish Laboratory.



Photo, Hayles, Cambridge.

Professor Sir J. J. Thomson, F.R.S.

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rapidly rotated and over which discs painted with the three primary colours were placed. These were so arranged as to give three coloured sectors whose areas could be altered at will. Two smaller discs, one painted with the colour to be matched and the other painted black, were placed over the others and the top rapidly rotated. The colours blended so as to give a continuous impression, and the areas of the sectors was altered until the outer ring matched the inner one. Two of his mechanical tops are shown in the same illustration. On one occasion he had been spinning one of his tops in his rooms at Trinity College for the entertainment of some of his friends, and when the party broke up the top was left spinning on the hearth. Next morning Maxwell, seeing one of his friends coming across the court, jumped out of bed, re-started the top, and retired once more between the sheets, thus earning for the top a reputation which was the talk of his friends for some time afterwards. The fourth piece of apparatus in the figure has an interesting history also, although unconnected with the Cavendish. It is one of the very earliest thermometers, in which temperature was measured by the expansion of a liquid in a glass envelope, and was probably constructed by Rinieri, a pupil of Galileo, in Florence, in the 17th century. By means of this and similar thermometers a large number of observations on climate, etc., were made by the members of the Academy del Cimento, but all the thermometers were subsequently lost, and, as they had been graduated on an arbitrary temperature scale, the observations could not be interpreted. Fortunately, many years after, several of his thermometers were found, and this one was presented to the Cavendish Laboratory.

Upon Maxwell's death, in 1879, Lord Rayleigh was elected to the vacant Professorship, and while he held it the Cavendish School of Physics increased its reputation both on account of his own work and of the work done under his supervision. His is a versatile genius, and among the various subjects which he has attacked from time to time there are many which have an interest wider than the scientific one—the discovery of the rarer constituents of the atmosphere, his researches on acoustics and their bearing on music; these and many others attract us, but we must not on that account under-rate the more prosaic work which he carried out during his stay at the Cavendish. This consisted principally of a re-determination of electrical units—a research attaining such accuracy and finish as to have become classic.

In 1884 Lord Rayleigh left Cambridge to become Professor of Physics at the Royal Institution in London, and the electors to the Cavendish Professorship were left with the uncommonly hard task of choosing a successor to Clerk Maxwell and Lord Rayleigh. The chances of success must have seemed small, and yet we know now that by a happy inspiration they made a wise choice and selected a man who was able not only to maintain the high traditions, but even to add greatly to them. The new Professor, moreover, when elected had only distinguished himself in Mathematics, and in Experimental Physics he was practically untried. Now, of Professor Thomson's work even "the man in the street" knows something—if only that, among other things, he has "split the atom." Maxwell had maintained that researches on gases were the most likely to lead to definite information as to the constitution of matter, and the work of his successor has abundantly verified this prediction. By a masterly series of researches on the mechanism of the conduction of electricity through gases, he has shown that the process consists of a kind of electrolysis in which oppositely charged particles move in opposite directions, giving up their charges to the two electrodes. The carriers of the positive electricity have approximately the same mass as the atoms, while the mass of the carriers of the negative electricity is about one thousand times smaller.

These minute negatively-charged particles have since been found to be of almost universal occurrence, and, indeed, to be, in all probability, the raw material of which all the atoms are built up. The positively-charged particles, on the other hand, appear to be atoms which have lost one or more of these "electrons." The atom on this view consists of a number of these electrons held together and electrically neutralised by a positive charge. In any gas under ordinary circumstances two opposite processes are continually going on.

[*Photo. Hayles, Cambridge.*

Cavendish Laboratory—Original Buildings.

Atoms are parting with electrons or "ionising," as it is called, while at the same time the positive and negative ions thus formed collide from time to time and recombine. The result of these opposite processes is that a balance is soon reached between them, after which the number of free ions in each unit volume of the gas remains constant. Thus a gas is always a conductor of electricity, although its conductivity is so small that special methods are necessary to verify the fact.

Professor Thomson has shown, too, that the pencil of rays coming from the cathode during the passage of an electric discharge in an exhausted tube consists of a stream of these small electrons. This conclusion was contested for some time—especially in Germany—but it

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has now been shown to be a true account of the phenomenon. For, in spite of the minute size of these electrons Professor Thomson was able to determine their mass, the magnitude of the electric charge which they carry, and the speed with which they move.

That so much information has been obtained about these small electrons—far more than we have acquired about the comparatively large atom—is due to the fact that they carry an electric charge. Thus, when moving in the space between two oppositely charged metal plates, they are acted upon by a constant force which deflects them from their straight path in much the same way as a stone is deflected from its original direction when thrown in the air. The amount of this deflection for the electron can be calculated in terms of its charge, its mass, and its velocity, and if we can

[Photo. Hayles, Cambridge.

Cavendish Laboratory—New Wing opened by Lord Rayleigh, June 16, 1908.

measure it we obtain a relation connecting these three quantities. Early experiments were unsuccessful, but Professor Thomson pointed out the defect in the arrangements, and successfully measured the deflection. This he did by observations on the stream of cathode particles in the discharge tube placed between two parallel metal plates. The position of the point where a narrow stream of these particles impinged on the end of the tube was indicated by a small green phosphorescent patch on the glass, and when the metal plates were charged this patch moved through a distance which could be easily measured. A stream of charged particles behaves exactly like an electric current, and so can be deflected not only by charged plates, but also by a magnet. This magnetic deflection was also measured by Professor Thomson, and so a second relation connecting the charge, the mass, and the velocity of the electrons was obtained. From these two relations both the velocity and the ratio of the charge to the mass could be determined. The velocity was found to be about 3×10^9 centimetres per second—about one-tenth of the velocity of light—while the ratio of the charge to the mass was found to be about 1,700 times the corresponding ratio for the hydrogen atom in electrolysis. This was an extremely interesting result, indicating, as it did, that the electron either had a mass very much smaller than that of the hydrogen atom, or carried a charge very much larger. Professor Thomson decided between these two alternatives by determining independently the charge carried by an electron. In this case the electrons used were these produced in air and other gases by radium or Röntgen rays, their identity with the cathode particles being beyond doubt. The method was based on two previous discoveries, a theoretical one due to Sir George Stokes, who showed that from observations on the velocity with which a cloud settles the size of the drops can be calculated, and an experimental one by Mr. C. T. R. Wilson that the electrons could act as nuclei for the formation of a cloud. Some dust-free air, saturated with water vapour, was caused to expand suddenly. This expansion cooled the air, and that portion of the water vapour which it was no longer able to hold condensed on the electrons to form a cloud. The cloud settled sufficiently slowly for fairly accurate measurements of its velocity to be made. This gave the size of the drops, and, therefore, the quantity of water contained in each drop, and, dividing this into the total quantity of water deposited—calculated from the amount of the expansion—Professor Thomson obtained the number of drops and, therefore, the number of electrons in each cubic centimetre of the gas. Observations on the electric current between two plates in the gas, made under the same conditions as when the cloud was formed, gave the total electric charge carried by the electrons in a given time. But the number of electrons was known, and this, with other data previously determined, gave the charge carried by each electron. It proved to be the same as that carried by the hydrogen atom in electrolysis, thus suggesting an atomic structure for electricity with this charge as the atom. On this view all monovalent ions in electrolysis carry one atom of electricity, while divalent ions carry two atoms, and so on. It was at first supposed that the whole mass of the atoms was due to the corpuscles contained, the hydrogen atom probably containing about 1,700, and the atoms of other elements more in proportion to their atomic weights; but Professor Thomson has since shown that the number of corpuscles in an atom—or, at any rate, the number whose presence is indicated by phenomena of conduction of electricity and heat, and by certain optical phenomena—is probably not very different from the number expressing the atomic weight of the element. Thus, the positive charge on the atom seems to play a more important part in determining the mass of the atom than was at first suspected.

Professor Thomson also showed that if a charged particle were in motion it had an apparent mass, due to its charge. The reasoning by which this result is reached is beyond the scope of the present article, but a mechanical analogy may make the matter clearer. Suppose a mass-less sphere to be moved through a fluid, it would be found to behave exactly as if it had mass, *i.e.*, it would require a finite force to give it a finite acceleration. This is due to the fact that the sphere carries a certain definite mass of fluid with it. In the same way

we may imagine the electron with its system of tubes of force radiating out from it to grip and carry with it some of the ether, through which it is moving. An interesting deduction from this is that the apparent mass of an electron ought to vary with its velocity, being nearly constant for small velocities, but increasing rapidly as the velocity approaches that of light. When this inference was first drawn it was impossible to obtain electrons moving with a velocity great enough to make possible any test of its validity. The discovery of radium solved the difficulty, however, as the β rays were shown to consist of a stream of these electrons, some of them moving with a velocity nearly as great as that of light. These electrons were found to have a mass apparently greater than that of the slower ones. Professor Thomson calculated the mass which ought to correspond to the different velocities on the assumption that the mass of the electrons was entirely of this electrical nature, and the observed values agreed with these calculated ones to an accuracy quite surprising. Thus, there is considerable evidence for the view that mass is electrical in origin, and in this case the mass of a body is not concentrated in the body itself, but is distributed all through the universe. This conception constitutes a most important advance in our view of the constitution of matter, amounting, as it does, to an identification of mass with electric charge. Recently, Professor Thomson's work has been mainly directed towards the elucidation of the nature and properties of positive electricity—a problem which has proved much more difficult than the corresponding one for negative electricity. Among his more important published works may be mentioned "Applications of Dynamics to Physics and Chemistry," "Recent Researches in Electricity and Magnetism," "Conduction of Electricity Through Gases," "Corpuscular Theory of Matter," and the series of Text-books of Physics, which he is bringing out in collaboration with Professor Poynting.

But we should do an injustice to the memory of the students who have worked in the laboratory, as well as to the Professors who have guided them, if we failed to acknowledge the part they have played in making the Cavendish what it is. During the earlier years they were few in number, but later on, when Cambridge offered facilities to graduates of other universities to come as advanced students, the numbers rapidly increased, until now there are about thirty men engaged in original work. The temptation to name some of these is a strong one, but the full list of their names is almost infinite now, and it is essential that this article should be finite. They form a descending scale of such small gradations that even if we could be quite certain of naming the greatest of them there would be no obvious place to stop until we had completed the list. They came to the Cavendish from all quarters, absorbed its spirit and its traditions, and went forth again to Professorships and other scientific posts all over the world. Some of them were Professors of standing before they came, but few have gone away without acknowledging their indebtedness to the institution and its head. Science possesses few personalities more striking and attractive than that of Professor Thomson. His enthusiasm is infectious, and his unbounded energy impresses all who come into personal contact with him. He lectures to his advanced class, making scientific history as he goes; he lectures to his elementary class on Properties of Matter, giving them a liberal education; he does the thinking for his own researches, experimental and theoretical, and is always ready to do some for the twenty or thirty men whose work he supervises; yet in spite of it all he has more time for other interests than most men. How he does it is a mystery. When he sleeps, or, indeed, whether he ever does sleep, his students cannot say, but the fact remains that in recent fiction, in the drama, in sport, and in politics, he is abreast of the times and ready to be entertaining or entertained on one or all of these topics. The personal relations between Professor and students have always been of the warmest nature. Tea in the Professor's room—a daily function for the research students—is made the opportunity for free intercourse, and any suggestion of stiffness or formality is banished. When the Professor received the Nobel Prize, nowhere was the rejoicing more keen than among his own students, and if the enthusiasm over his recent knighthood is less warm it is only because it is felt to be a hardly adequate recognition of the man and his achievements.

Of the buildings themselves little need be said. The original central portion, built in Maxwell's time, is shown in the illustration. As the study of physics became more general the demand for space became urgent, and the need was met by the erection of a large demonstration room—shown in the illustration—and an additional lecture-room. Even this accommodation was rapidly outgrown, and both research and the ordinary teaching work were hampered until the new wing, largely due to the munificence of the former Cavendish Professor, and present Chancellor of the University, Lord Rayleigh, was opened by him in the summer of 1908. The provision for the work of the laboratory is now once more adequate, and it is undoubtedly entering upon a new era of success under the man whose 24 years' association with it has done so much to make it famous.

UNIVERSAL PROJECTION APPPARATUS.—Messrs. Leitz, of Wetzlar, have constructed and sent to England for use in one of the physiological schools of London University, an example of the latest development of the Projection Apparatus which was designed in accordance with the suggestions of Professor Kaiserling; and till a few days ago it was on show in their rooms in Oxford Street. The apparatus, as students will be aware, is designed so as to fit it for several distinct purposes. It can be used as an ordinary projection lantern, with high-power microscopic attachments; or for the episcopic projection of images of objects which are placed on a horizontal plane below the axis of the lamp; or for the lateral episcopic projection of objects placed at the side of the apparatus. The second of these classes of projection would enable an image of the skin of a person standing by the side of the apparatus to be shown on the screen. Apart from the immediate purpose of projecting horizontal objects floating in liquid, the arrangement has the advantage that lantern slides or sections up to 210 mm. in diameter may be projected simply by placing them on the condenser lens. There is also an attachment for the projection of spectra. The chief attractions of the apparatus lie in its adaptability and wonderful compactness, which both evince the constructive ability of an operator whose ingenuity has been stimulated by long acquaintance with the necessities as well as the possibilities of optical demonstration. The versatility of the instrument enables a lecturer to pass from one mode of projection to another with the least possible loss of time; and, compared with the possibilities of an old-fashioned optical lantern this piece of projection apparatus is as superior as is a modern tape telegraphic transmitter to an obsolete dot and dash key instrument.

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The Birth and Death of Worlds.

By F. W. HENKEL, B.A., F.R.A.S.

IN a forest we find co-existing evidences of life in all its stages, from its earliest development to the last signs of death and decay. There are the nuts and seeds, the germs of future plants, then the young and tender saplings, next the full-grown adults. Here and there we come across the "giants of the forest," vast trees with rings denoting hundreds of years of growth. Later in the stage of life we find the old moss-grown oaks, etc., that the next storm will bring to the ground, and last of all the decayed and fallen remains of former life. The same thing is true of the starry heavens. Here we find worlds in every stage of growth, development, and decay. There are the nebulæ, worlds just coming into being, the "white" suns (of which Vega is a good example) in intensely hot youth; next, worlds like our own sun, in a somewhat later stage of growth, but still very hot and luminous; next we have worlds growing old and darker, such as many of the red stars appear to be doing; and lastly "dead" worlds like our own moon. Some points in this classification may be open to question, for it is not by any means certain that red stars, for instance, are cooling down always; they may sometimes be growing hotter, at least for a time, and nebulæ do not always develop into stars, but the above is the generally received order.

Naturally, in all this the past and future history of our own earth concerns us most. Nothing can be more certain than that at one time its surface temperature was much greater than at present. The existence of fossil remains, in temperate regions, of animals and plants now only found in hotter climates, the igneous and metamorphic rocks, the increase of temperature as we go downwards towards the interior, the phenomena of earthquakes and volcanoes, are all witnesses to this. Recent severe volcanic eruptions and earthquakes show that though cooler, our earth is by no means a dead world. The earth is, however, but one of a number of bodies in motion round a predominant and central body, the sun. We find this system arranged in an orderly manner, the members of it moving in nearly circular paths round the centre, these paths lying nearly in the same plane, and they move generally in the same direction, and are, on the whole, placed at an approximately regular progression of distances from the sun. These relations are by no means a consequence of gravitation, and imply an original connection between the bodies moving. To account for these phenomena suggestions were made by Swedenborg, Wright, and Kant, the great philosopher of the 18th century, and a more elaborate hypothesis on similar lines was brought forward by Laplace, the greatest mathematician since the days of Newton.

Laplace supposed that at one time the matter now forming our earth, the sun, and the other planets was in the form of an intensely hot gas (or nebula, whence the name of the Nebular Hypothesis). This primeval nebula was of approximately spherical form and rotated slowly on its own axis, the rotation becoming swifter as the mass of the nebula grew colder and contracted. In time rings of matter would be left behind; each of these rings would gradually collect into a single globe, and thus the planets would be formed. A planet thus formed, continuing to revolve, might itself abandon rings in contracting, and these rings would form into the satellites. The rings of Saturn were at one time supposed to be an illustration of this idea, but though it is possible they may have been formed in this way, we know they are rather clouds of meteorites than continuous substance. The "exceptional cases" of the solar system, the fact that the satellites of Uranus and Neptune do not move in the same direction as the other members of our system, and the swift revolution of the inner satellite of Mars cannot be explained by this form of the Nebular Hypothesis. M. Faye, however, by modifying the original idea of Laplace, and supposing the planets to be formed by local condensations (not by the detachment of rings), and that the inner planets, Mercury, Venus, Earth, etc., are older than the outer ones, Uranus and Neptune, has shown that the former would have direct rotation on their axes, the latter would move in the retrograde direction which he supposes to be the case with the rotation of Uranus and Neptune, from the retrograde revolutions of their satellites. Since, however, Saturn's rotation is in the same direction as that of our earth, and yet the last discovered satellite moves in the opposite direction, we have still a difficulty, unless we suppose this to be a *recent capture and not an original member of the Saturnian family*. Professor Sir George Darwin, by his theory of Tidal Evolution, has shown that, say, in the case of Mars, its period of rotation on its axis may have been the same as that of its satellite's revolution, but that tidal friction has gradually retarded the rotation till it has reached its present value. In the case of the moon, he shows that millions of years ago the earth was probably rotating at a much greater rate than at present. At one time earth and moon formed one body, but, in contracting, a portion of the earth separated from the rest, and gradually receded to its present position (by a reaction equal and opposite to its tidal action on the earth), and became the moon. The ancient Arcadians are said to have declared that their race *came into existence before the moon*, but they probably did not imagine the period they claimed for their ancestry (fifty-seven million years)! Though, as we have stated above, Laplace's Nebular Hypothesis with the modifications proposed by Faye and Sir G. Darwin's "Tidal Evolution" accounts for many of the peculiarities of our system, yet, as it was propounded before the discovery of the conservation of energy and thermodynamical principles, it is not surprising that it should need further modifications. Our knowledge of actual existing nebulæ leads us to consider that the original nebula from which our system has developed was comparatively cool, instead of being much hotter than the sun is now. By Lane's law a gaseous mass condensing would rise in temperature, and it is probable that the original nebula was largely composed of meteorites which, by collisions during their gradual drawing together, would grow hotter and hotter. After a time the central mass would form an intensely hot "white" star. Later on the loss of heat from radiation exceeding the gain from contraction and condensation, the star would cool down and finally become a dark body, like the companion of Algol. The planets, being smaller than the star or sun round which they revolve, will cool down at a very much quicker rate, solidifying at their surfaces and more slowly losing heat from their interiors, becoming non-luminous bodies. Our earth and the inner planets seem to have reached this stage, but Jupiter, Saturn, Uranus, and Neptune appear to be still incandescent, self-luminous to a certain degree.

The late Mr. Proctor often spoke of the planet Jupiter as a "semi-sun," and Zöllner has shown that the light given out by this planet is more than could be expected to be due to mere reflection of sunlight alone. Later

still in the stage of development appears the moon, which has apparently lost such air and water as it once possessed. Evidence of its former activity is to be found in the extinct craters seen everywhere over its surface, but now the stillness of death seems to prevail. Such as the moon is, it is supposed the earth will be, and later on the sun, too, will become a "cold, dark ball." Estimates as to the past and the future duration of our system have been formed by Lord Kelvin and others, but the very various lengths of time given, ranging from 20 to 400 millions of years, alone show that all such estimates are little more than rough guesses, needing further knowledge to be of value. The discovery of the properties of radium has enormously extended the probable future duration of the sun's heat. "We have every reason to think," says Arrhenius, "that the chemical energy of the sun will suffice to maintain the solar heat during thousands of millions, and, possibly, billions of years! So enormous a lengthening may seem to indefinitely postpone the existence of our system. Yet the end must come at last, *provided there be no compensating causes at work.*

Of the heat radiated by the sun only about one two-thousand millionth is received by our earth, and yet even this small fraction suffices for our needs, a large amount of it, too, being ultimately lost to us. By far the greater portion of the sun's heat is radiated out into infinite space, and, in accordance with the ideas that have hitherto held ground, this energy is being gradually dissipated. The hot bodies of the universe are getting colder, the cold ones, perhaps, a trifle hotter. This tendency towards uniformity of temperature causing a loss of available energy, for heat of itself only passes from hot bodies to colder ones, never the reverse (Second Law of Thermodynamics), it is supposed that a state of stagnation or universal death of the Universe will arise. But the present writer, not alone, has always felt that this view is unsatisfactory. On philosophic grounds Herbert Spencer was convinced there must be cycles of growth and decay in the evolution of the Universe. Moreover, it may be asked. how is it that the Universe is not dead already; if it has existed from eternity there has been an infinite time for this dissipation to take place? On the other hand, we may say that nothing whatever can be postulated as to an Infinite Universe at all, except that if it be infinite, the dissipation of its energy (or conversion into uniform heat) must take an infinite time, and so the "death of the Universe" will never come off at all.

We are now, however, led to a happier and more healthy view. Though it is true that the hot bodies (the suns) of the Universe are growing colder by radiation, this radiant energy is absorbed and preserved by the dark stars and the nebulæ at low temperature. Of recent years it has been shown that the quantity of dark and faintly luminous matter in the part of the Universe which alone we can reach with our telescopes is far greater than was formerly supposed to be the case. Photographs of regions of the sky taken after long exposures have revealed the existence of nebulous matter utterly unknown before. The well-known group of the Pleiades "is wrapped and entangled in an immense cosmical cloud." Some of the nebulæ revealed by the photographic camera have never yet been seen by human eye through the telescope. The phenomena of variable stars such as Algol are best explained by the existence of dark companions, sometimes larger than their accompanying luminary whose light they wholly or partly eclipse. There are other grounds, too, for assuming the existence of countless dark bodies throughout space. If we suppose the Universe to be infinite in extent, a line of sight drawn in any direction must sooner or later meet a star, and thus the whole sky should be everywhere bright, unless we suppose the "ether" to be imperfectly transparent or dark bodies in the way stopping the light. Since star light is only a small fraction of sun light the number of such dark bodies must greatly exceed that of the luminous ones. In this respect we are unable to agree with Miss Clerke that the feeble total of stellar luminosity betokens a limited Universe. Our own Milky Way may well be of limited, though enormous dimensions, but even it was declared by Herschel to be *fathomless* in parts. Imperfect transparency as well as the presence of dark bodies may put limits beyond which no telescope can penetrate, but it seems premature to say what future generations may or may not discover.

The sun (and all other luminous stars) radiating heat and light into space, this radiant energy is not lost, but is constantly absorbed by the colder portions of the nebulæ and dark bodies of the Universe. "Every ray emitted by a sun is absorbed, and its energy transferred through the gaseous particles of the nebulæ to suns that are being formed in the neighbourhood of, or within, the nebulæ." Now and again collisions of dark bodies must occur, resulting in the evolution of immense heat and light, and the phenomenon of a "new star" is seen. A series of successive (comparatively) slight collisions will account for some of the phenomena of irregularly variable stars, many of which seem involved in nebulæ, within which many other more or less dark bodies are contained. Two colliding suns give birth to an enormous mass of gaseous matter surrounding a somewhat more condensed nucleus, and under the influence of gravity and "radiation pressure of light" the process of evolution once more goes on "in an eternal cycle in which there is neither beginning nor end." Such, at least, is the opinion of Arrhenius, upon whom the University of Cambridge has just conferred its honorary degree, and there is much to be said for this view of the matter. Under the influence of gravitation matter tends to concentration in vast centres, but this is counteracted by the scattering action of the light pressure. This idea of the balancing of contrary tendencies is a very ancient one, and we well remember being told of the two "forces," attraction and repulsion, by which the world is kept going; the philosophic notion is at least as old as Aristotle. "Solar systems are evolved from nebulæ; nebulæ, in their turn, are produced by the collision of suns."

Round the suns circulate smaller bodies, the planets, and these, cooling more rapidly than their central orbs, become fitted for organic life. All theories as to spontaneous generation or special creation of existing species being without scientific foundation, and the Darwinian theory of evolution meeting with general acceptance, we may at least consider it possible that the present species may have originated from a few simple types, or even from one organism. The late Lord Kelvin supposed that life may have been brought into our planet by germs contained in meteorites falling upon its surface, but there are difficulties in the way of this view. The high temperature generated by meteoric collisions would most probably destroy any such germs should they be originally present. However, Schwarzschild has shown that by the agency of sunlight minute organisms not much smaller than the spores of known bacteria can be sent forth into space, and might thus fall upon planets and give rise to life under favourable

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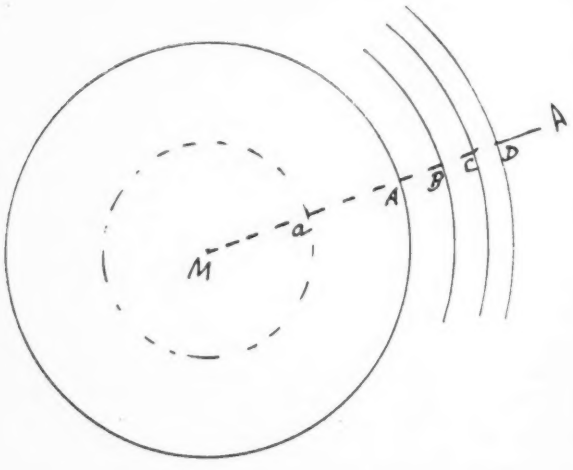
conditions of temperature, soil, etc. Since micro-organisms have been kept for months in liquid air and also in liquid hydrogen at temperatures below —250° C. (420° F. below zero) without losing their power of germinating, even the cold of space might not kill them. In answer to the question how such spores could escape from a planet against the effect of gravitation, it has been supposed that electrical forces may be the acting cause, repulsive charges on other particles causing the "spores" to be driven forth. We know that the phenomena of auroræ, comets' tails, and probably sunspots also, indicate the widespread prevalence of electric agency, far outside our own planet, but still it must be admitted that this invocation of new agencies is a weak point in the hypothesis.

According to this version of the hypothesis of "panspermia," all organic beings should have a similar basis and be composed of "protoplasm," or, at least, hydro-carbons. In this manner life may have existed from all eternity, and its germs carried from system to system, developing into plants and, later on, into the higher animals, when conditions are favourable. In the Universe of God we see no signs of beginning or of end; so, too, we may well believe that the principle of life has for ever existed. Under His guiding hand we see it has developed into the various forms with which we are cognizant on our planet, and into countless other forms, no doubt, in the regions of space. It may well be that in other and older worlds beings exist as far transcending ourselves in mental (and, perhaps, bodily) perfection as the complexity of our bodily organism transcends that of the humble unicellular alga or amœba.

Distribution of Matter Through Space.

By PROFESSOR TARRIDA DEL MARMOL, B.Sc., C.E.

THE theory of a limited Universe, based on the infinite quantity of light which should be sent to us by an infinite number of stars, has been strongly assailed on mathematical grounds by an application of the theory



of the convergent series, and in the observation field by the fact that there is certainly a considerable number of dark bodies which may act as light absorbers.

But this last objection fails against the argument lately suggested by Mr. Owen Ely, who points out the fact that whatever substances there may be in the Universe which absorb light, there is none which impedes gravitation. Then, in a nearly homogeneous infinite Universe, the stars might not send us an infinite light, but they should certainly exert on us an infinite gravitational action, in comparison with which that of the sun would be *nil*, a fact contrary to evidence.

In the case of the distribution of matter being heterogeneous it may be shown, with the help of the theory of the convergent and divergent series, that our Universe must, also in this case, be limited.

But what may be the distribution of matter beyond our Universe?

Let MA = 1 be the radius of a sphere which contains our Universe Ma, and a portion aA of the absolute vacuum limiting it.

Let us consider the spheres MB, MC, MD . . . whose respective radii would be

$$\sqrt[3]{2},\ \sqrt[3]{3},\ \sqrt[3]{4}\ \ldots$$

The spaces comprised between two successive spheres are all equal to

$$\frac{4}{3}\pi\left\{\left(\sqrt[3]{n}\right)^3-\left(\sqrt[3]{n-1}\right)^3\right\}=\frac{4}{3}\pi\ (n-n+1)=\frac{4}{3}\pi,$$

that is, equal to the volume of the sphere MA.

Since in this space MA there is a portion devoid of matter and a portion provided with it, we may admit that there is a possibility, say, a probability, as small as you like, $\frac{1}{p}<1$, that there is some matter in any one of these equal spaces AB, BC, CD . . . ., and also a probability $\frac{1}{q}<1$, that there is none (the sum $\frac{1}{p}+\frac{1}{q}$ being equal to the unity, which represents certainty).

The probabilities that such facts happen in 2, 3 . . . n spaces simultaneously would be, respectively,

$$\left(\frac{1}{p}\right)^2,\ \left(\frac{1}{p}\right)^3,\ \ldots\ \left(\frac{1}{p}\right)^n$$

and

$$\left(\frac{1}{q}\right)^2,\ \left(\frac{1}{q}\right)^3,\ \ldots\ \left(\frac{1}{q}\right)^n$$

But, since $n=\infty$ and $\frac{1}{p}<1$, $\frac{1}{q}<1$, we have:

$$\left(\frac{1}{p}\right)^n=0 \text{ and } \left(\frac{1}{q}\right)^n=0$$

So the probability that every one of those division of the infinite space is provided with matter is *nil*, and the probability that every one of them is devoid of matter is also *nil*.

It may be shown, by a similar process, that the probability of the number of limited portions of matter being limited is also *nil*.

Thus, the application of the theory of probabilities to the problem of space leads us to assume:

That there is in the infinite space an infinite portion devoid of matter, surrounding an infinite number of finite Universes.

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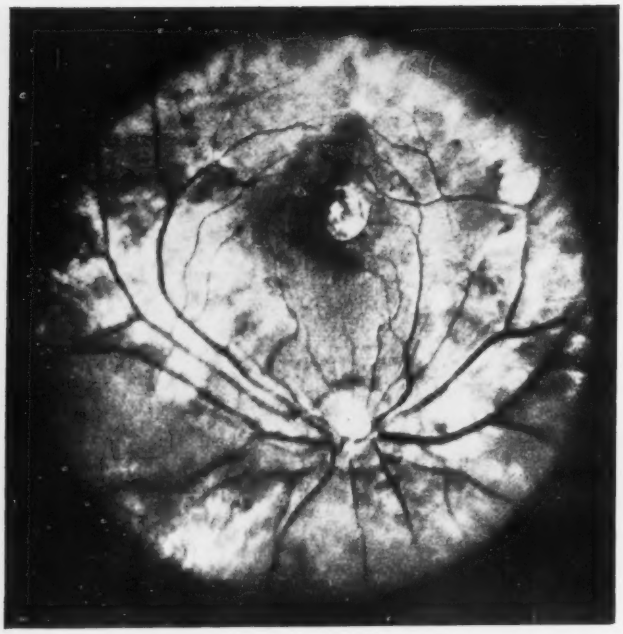
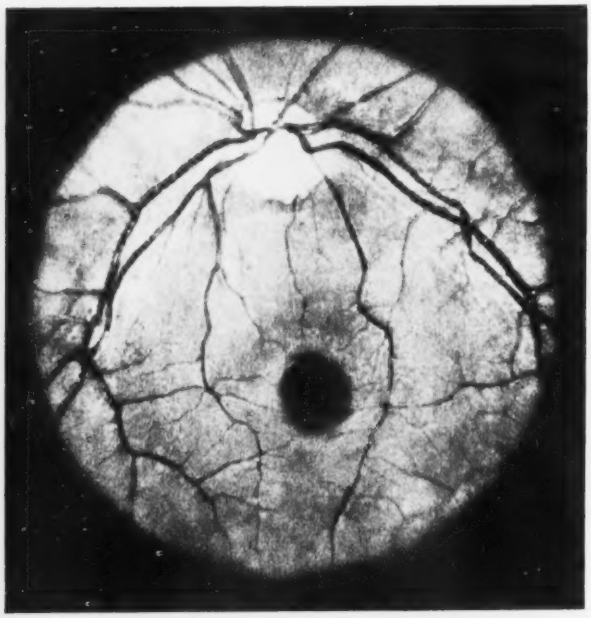
The Human Eye.

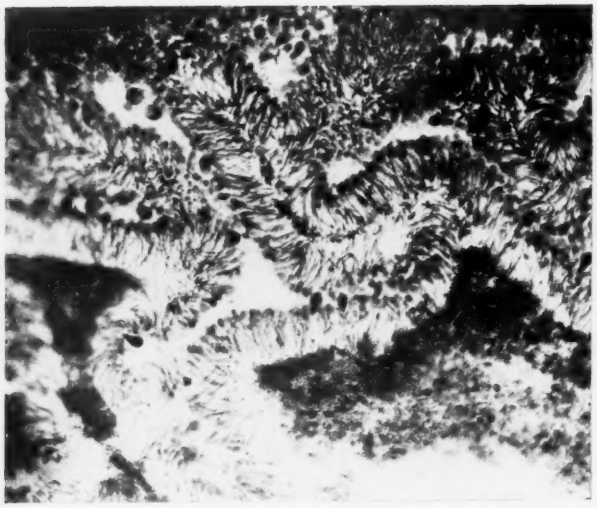


Back of Eye affected by chronic alcoholism.

Back of Normal Eye.



Back of eye affected by tuberculosis.



The human retina, showing rods and cones and accumulation of pigment.

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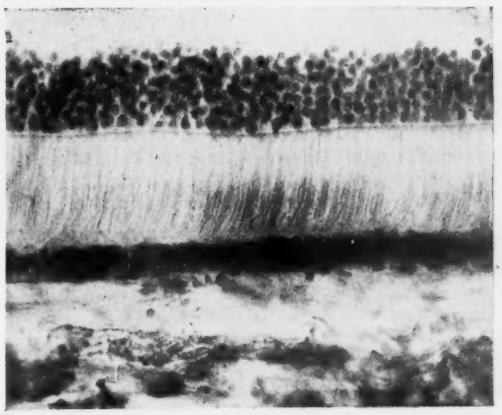
The Human Eye.

What May be Seen at the Back of It.

By F. SAVORGNAN DI BRAZZA.

THE eye of all the superior animals, including that of man, is nothing more nor less than a "dark room" of such perfection that the cleverest manufacturer of optical instruments and photographic cameras could not hope to copy it. The globe of the eye consists, as everyone knows, of a kind of sphere, flattened on the upper and under side and possessing a prominent anterior part, called the cornea. It may be considered as being composed of four special parts. I.—A protective part, represented by the anterior part of the cornea and the posterior part of the sclerotic coat. II.—One of vision, consisting principally of the retina. III.—One of reflexion, consisting of a number of transparent membranes, the crystalline lens, aqueous humour and vitreous body. IV.—The apparatus of *accommodation*, which permits objects at different distances to be distinguished, and is represented by the ciliary processes and the conjoined crystalline lens. The latter, by means of an appropriate system of muscles, is able to augment or diminish its transverse diameter according to whether the object to be seen is near or far off. No photographic camera possesses such a perfect object-glass as that of the human eye; no camera can be fitted with an apparatus of such instantaneous focus, based on a simple modification of the curvature of its lenses.

The rays of light penetrate the eye and reach the retina by passing through the refracting media, and their quantity is regulated by the iris, which works in the same way as the diaphragm of the photographic camera. The perception of surrounding objects is accomplished at the back of the eye by means of the aforementioned nervous membrane, the retina. At the point where the optic nerve penetrates the eyeball, its numerous fibres spread out like a fan, branching out to infinity and, radiating in all directions, arrange themselves in a uniform manner. At their extremity are found the cells of vision, which, on account of their respective shapes, are called *cones* and *rods*. The function of the two kinds of cells is quite different. The cones are found in the *fovea centralis*, at the point where the perception of objects is accomplished through the concentration of the rays of light. The rods, on the other hand, are found at the edge of the retina, thus forming the circle which surrounds the fovea. On the boundary between the two parts are found cones and rods mixed together. A clever young Italian oculist thinks that the rods are merely young cells which become transformed by degrees into cones, taking the place of any of the latter which die off. Such are the visionary cells properly so called. A clear and explanatory group of rods and cones is shown. They can easily be distinguished one from the other by the latter being pear-shaped. The normal retina is perfectly transparent; when examined, however, in semi-darkness its colouring is reddish purple, owing to the presence of a pigment of that colour (rhodopsin). The existence of this reddish purple pigment is of the greatest importance in distinguishing different-coloured objects. The granules of the pigment are extremely movable according to the light which strikes them. Dr. Angelucci, while studying in frogs the migration and stratification of the granules in connection with monochromatic rays of light, discovered that from the effects of a single colour the granules arrange themselves in direct relation to the rays which strike them, from red to violet, and this is equivalent to saying that at each instant a ray of light produces a corresponding effect and afterwards gives the same sensation. This fact has complete analogy with a well-known physical phenomenon which was applied by the French scientist, Lippmann, in the production of his system of coloured photography. This system, called "interferential," is one in which the incidental light which forms the image on the sensitised plate is reflected by a mirror in such manner that the two incidental lights and the reflexion "interfere" with each other. There are thus formed, as has been pointed out by Dr. Newhaus, stratifications in the sensitised gelatine, according to the different colours which strike it. After death the retina turns to an opaline or slightly grey tint and changes rapidly. The pigment is found specially in the *fovea centralis*, situated in the centre of the cells of vision in the posterior pole of the eye. This region is called by oculists the *macula lutea*, or "yellow spot." Above the rods and cones is found a last stratum of substance, the brown pigment of the eye, or *tapetum nigrum*.



Granulated stratum of the interior of the retina (cells of vision), rods and cones.

The back of the eye, and especially the retina, by reason of its importance in sight-production, has long been the object of intricate study. Since 1851, when the invention by Helmotz of the ophthalmoscope gave the first opportunity of genuine scientific research, discoveries have followed fast on one another. Obstacles have certainly been met with in dealing with so delicate and extremely changeable an organ, and one which can with difficulty support a prolonged examination without risk of serious changes, to say nothing of dangerous and painful accidents to the patient. Although the ophthalmoscope permits us to look into the interior of the eye itself, it is possible to obtain only transitory observations by its means. Permanent facts, which are of great importance in the study of every science and in this case of peculiar interest, are unobtainable with the ophthalmoscope. It was, therefore, decided to turn to photography as furnishing the best means we have in our power of obtaining conclusive evidence of the construction of the back of the eye.

Many attempts were made in this direction, and in 1862 a French oculist, Noyes, succeeded in getting photographs of the back of the eye, but these were poor specimens. The results of the studies made by Liebreich, Sinclair, Cohn, and Hope on the human eye and that of the cat, rabbit, etc., only proceeded one step

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further. It was not till 1887 that an American scientist, Professor Hove, of Buffalo University, succeeded in obtaining the first real photograph of the back of the eye. This was still a very imperfect picture as to detail, but it was a first step, and with science, as with so many other things, it is always the first step that counts. One of the greatest obstacles encountered in photographing the back of the eye is one which had also been the stumbling block in the case of former attempts. This is the great difficulty of illuminating the back of the eye sufficiently to allow a picture to be taken. The illumination must be sufficient yet not excessive, as in the latter case there is danger of producing modifications in the retina so that a true photograph of the back of a normal eye will not ensue. Professor Cohn, who has for the last twenty-three years been actively studying the subject, had in 1888 manufactured a special camera fitted with appropriate prisms, but this did not give good results, although not an absolute failure.

In 1889 Professor Bagneris, of the University of Nancy, used an equilateral prism for the illumination of the eye; many other attempts were made by different scientists, but it was not until 1891 that a really clear photograph of the retina was obtained and one of scientific interest. This was the work of Professor Gerloff, and was presented by him, on October 17 of that year, to the Physiological Society of Berlin. This first photograph has now an historical interest, and for this reason it is mentioned. In order to obtain such a photograph the patient was put to a veritable torture, as the following mode of procedure will show.

The eye was, first of all, benumbed with cocaine, then a small basin full of a solution of iodide of sodium was placed in front of the orbit and held in suspension there by means of strips of plaster fixed round the head. The head was then fastened to a support, and the absolute immovability of the patient being secured, he was made to hold a large piece of wax between his teeth. The assistants at this torture of the inquisition naturally tried to find a method which would be less painful and at the same time more certain. Examples of the various attempts at the construction of a suitable apparatus are the one manufactured by the French doctor, Guilloz, in 1893, and that by Thorner in 1896.

The credit of having discovered a machine which is both practical and simple in construction and working belongs to the Doctors Bonacini and Borghi, of Modena, who, in 1898, presented to the Surgical Society of Modena three splendid photographs, taken with their apparatus, of the back of the eye. The construction is as follows: The source of light A has its rays reflected by a mirror B, they then pass on to illuminate the back of the eye N through the plano-convex lens D. The image given through the lens D can be seen very clearly by means of the ophthalmic mirror, and can be photographed with an ordinary camera. With the invention of the two doctors of Modena was solved in a simple manner the problem of the illumination of the back of the eye. In the instrument of Bonacini and Borghi the source of light is really composed of two distinct parts, one for inactive light A which, as everyone knows, does not injure the eye and by the light of which the eye is focussed, while the second part A gives a much more vivid light, and is used only at the moment of taking the photograph. This is done by means of an appropriate stop.

A special ophthalmoscope was, in 1902, invented by Professor Walter Thorner, of Berlin. The instrument was constructed in such a way that the eye could be studied and photographed at the same time. Quite recently Dr. F. Dimmer, of Graz, thanks partly to the large amount of moral and financial support afforded him by the Kaiserl Academy of Wissenschaften, of Vienna, has constructed an apparatus which may be said to be perfection, and with it numerous very clear and valuable photographs have been taken, the exposures never lasting longer than the twentieth of a second. The series of Dr. Dimmer's photographs is the only one extant, and is quite unique. Thanks to his courtesy, the writer is able to show some of them here, as well as a picture of the apparatus which produced them.

The pictures obtained have proved beyond dispute that if the eye is rightly called the mirror of the soul, it may also be called, and with just as much reason, the mirror of the physical state of the body. In the eye, as elsewhere in the body, may be found symptoms of diseases such as consumption and alcoholism, which produce corresponding disturbances of the retina. This fact furnishes to science a new means of diagnosis more certain and rapid than any other. This is of great importance when it is considered that the greater part of the terrible diseases which afflict mankind are easily curable in their initial stage, whilst they become at a later stage incurable.

In conclusion it may be of interest to describe some curious conditions discovered recently and contemporaneously by several American scientists. It has already been gathered that the rays of light are the cause of the different modifications in the chemical properties of the liquid parts of the eye, in the orientation of the pigment of the retina, etc. Not only is this the fact, but it has also been found that the rays set up in the eye electric currents, which, on account of the part in which they develop, are called *retinal currents*. If the end of a copper wire be placed over the anterior pole of the eye and the other extremity over the posterior pole, just at the middle section of the optic nerve, and if a ray of light is made to fall on the eye, there will run along the wire an electric current from the anterior to the posterior pole. If the ray is very intense the current is strong and prolonged, but the eye does not re-act for some time. If the incidental rays are, on the contrary, weak, then every time a ray enters there is electric variation. The interesting fact is this, that the intensity of these currents produced in succession diminish in exactly the same way as the change which takes place in muscular fatigue.

The experiments of Professor Angelo Mosso, made with his ergograph, show that if a muscle is obliged to lift for a long time the same weight, it will tire little by little and at last will cease to work altogether. From the maximum to the minimum strength a curve may be drawn, and this curve is identical with that which shows the electric variations of an eye which is subjected to slight continuous stimulation. For this reason it has been asserted by some that the eye works and exhausts itself after death as it did in life, and, in fact, Woller thinks that all the electrical postmortem phenomena which are found in the muscles and nerves are nothing but the last manifestations of life.

Professor Bose disputes this theory hotly, saying that vital phenomena are not in question but simple variations in the arrangement of the particles of the body, as is verified by electric phenomena. Bose has come to this conclusion through his own experiments, by which he has demonstrated that all metals when beaten hard respond with an electric current, and that these currents do not develop when the metal is first treated with a narcotic anæsthetic such as chloroform or ether.

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The Colour of Some Wild Animals.

By H. ROBINSON, M.D.

PROTECTIVE mimicry in animals has long interested the amateur as well as the scientific naturalist. For one thing, it is capable of effective popular exposition without undue technicality, and of ocular demonstration both by the draughtsman and by exhibits such as those to be seen in the Natural History Museum at South Kensington. For another, it is susceptible of satisfying explanation by the theory of evolution, of which, indeed, it has always been a stout pillar, from the days of Darwin and Dr. A. R. Wallace downwards. So firmly established as an integral part of the argument in favour of natural selection are the observations that have been accumulated about numerous and diverse animals, that a real danger has arisen. It seems to have been taken for granted, and some even of Dr. Wallace's writings may be interpreted in this sense, that protective colouring is necessary to the continued existence of every species, and that, sexual selection apart, it is incumbent on naturalists to offer ingenious speculations in this sense to account for the appearance even of the most bizarre and conspicuous beasts. Thence it has been but a short step to the announcement of those speculations as further evidence in favour of natural selection, and of various assumptions made in the speculative processes as indisputable facts. It need hardly be said that to refute any such line of argument by pointing out cardinal errors in its premisses is by no means an attack on the principles of evolution, but rather the reverse. To show t' at certain animals alleged to be protectively coloured are not so need not disturb the conviction that there are many others of which the same assertion is absolutely accurate. For several corrections of current misunderstandings of this kind biologists are indebted to the veteran hunter and naturalist, Mr. F. C. Selous, who, in his recently-published "African Nature Notes and Reminiscences," exposes several fallacies far too long accepted as scientific truths.

Before turning in detail to these very important criticisms, and of the novel alternative hypothesis propounded, it is necessary very briefly to consider the first principles of natural selection as they bear on protective coloration. The universal acceptance of this theory is partly due to the fact that it is built up on two main postulates, both of which are in harmony with common experience. These are, first, that the characters of parents tend to reappear in their offspring by a process termed heredity; and secondly, as a qualification of this, that the members of one family or one litter are never exact counterparts of each other and of their parents. This property of variation extends to every attribute of the species, and is both progressive and retrogressive in tendency; that is, if the total of any given quality could be calculated which, according to the principle of heredity, the members of a family should each exhibit, it will be found that some will possess a slight excess of that quality, some a deficit, and some the exact amount. According as a variation in either direction or as no variation at all affords the individual an advantage, no matter how slight, in the struggle for existence, so will such a variation or the *status quo ante* in respect of that quality be preserved and perpetuated in the species. The result is the graduation elimination of the most unfit types, or qualities of a type; for as the same process of selection is held to proceed simultaneously and independently in regard to every possible attribute, it is the combination of numerous minute increments of advantage that will best protect its possessor and enable him to thrive and transmit to his offspring, still in varying degree, his useful qualities.

Now the question of advantage or disadvantage is governed entirely by the environment of the struggler; that is, by the whole of the adverse influences against which his struggle for existence has to preserve him. Each variation is almost infinitesimal in degree, and therefore gross and measurable changes are in nature extremely slowly brought about and extend over very prolonged periods of time. It follows that a material change in the environment, which may be very rapid, as by climatic changes through earth movements, or by the activities of man, may render useless permanent qualities acquired in this laborious way and make valuable others long discarded or novel altogether. Therefore, it is not to be expected that present conditions of environment shall always account for present attributes of all animals, whether as to colour, form, or any other quality.

That is, in the baldest possible outline, the theory which, after years of discussion, has now for a long time been accepted by all biologists. As applied to the protective coloration of animals, it is supported by innumerable observed instances of assimilation in appearance to animate or inanimate objects, and of comparative invisibility against the prevailing background. The hunted so dresses himself as to be as little evident as possible to the hunter, who must in his turn do the same to regain the lost advantage, or perish of starvation. Now a peculiar strength of the theory of natural selection is that it does not assume the hereditary transmission of acquired characters, which are accidental qualities impressed on the individual by the vicissitudes of his lot. Thus the loss of a limb, or the ability to read and write, is, as everyone knows, not transmitted by a parent to his offspring; whereas an extra finger, due to the ineradicable tendency to variation, not infrequently does re-appear in the next generation. Although the problem is very much more complex than might appear from this example, it is at any rate true that scientists do not admit the transmission of acquired characters. The importance of this point will be presently made plain. Be it noticed also that there is no warrant for assuming that all colouring in the animal kingdom must be protective unless it can be accounted for by sexual selection, which has been left out of consideration in order not to confuse the issue. The colour of any given animal may be a legacy from ancestors whose environment was totally different; it may be a matter of comparative unimportance as a protective measure in beasts which have developed unusual powers of sight, hearing, speed, armament, fecundity, or other qualities, which enable them to maintain their places in the struggle; it may be a matter of complete indifference, as, for instance, to the elephant, one of the few herbivora now existing not appreciably liable to depredation by flesh-eaters until the recent intellectual development of man. Finally, colours and forms which seem to us disadvantageous in the extreme may yet serve some purpose so far unsuspected.

It is from disregard of these considerations that

various statements which are frequently quoted as examples of protective mimicry, and incidentally as proofs of natural selection, have obtained popularity. The application of the principles of evolution has been overstrained by the attempt to account for every spot or stripe or shade as protective in purpose. Some of the ingenious suggestions thus produced are based on conceptions which are, in fact, erroneous. To recognise the great advantages to many animals of colour harmony with their surroundings should not prevent the admission that in other cases a striking and conspicuous coloration does not appear to prejudice its possessor. Thus it has long been noticed that many bush and jungle-haunting animals are spotted or banded in the coat, and it has been supposed, no doubt correctly, that these markings to some extent harmonise with the dappled background produced by the play of sunlight through an imperfect screen of foliage. The bush-buck family among the hunted, the tiger among the hunters, are familiar examples. But there is one family pre-eminently more banded than any other on the globe, banded in a peculiarly aggressive manner, to wit the zebras. To account for the black and white stripes of these animals on a protective basis must have proved at first a difficult problem, until someone well acquainted with the species published a statement that the individual stripes are no longer visible to the human eye at a distance of three or four hundred yards. The statement is quite true, even of Burchell's zebra, in which the stripes are widest and the black and white colours of exceptional purity, and is only an example of a well-known phenomenon known as irradiation; but it has been seized, and held to prove the paradox that this animal is rendered inconspicuous by his stripes. The sunlight-through-the-leaves argument was once more dished up, and so the zebra is proclaimed as a very triumph of protective colouring. Nothing could be more opposed to the truth; because the stripes cannot be distinguished at a short distance it does not follow, and it is not a fact, that the resulting blend is inconspicuous. With the sun on him, the zebra presents a unique and quite characteristic whitish grey colour which arrests attention at great distances; with the sun behind him he appears dark and still very easily visible. Moreover, anyone who knows the zebra in his native haunts knows that he lives on flat, bare plains in large herds, and that to speak of him as protected by resemblance to an arboreal background is merely ridiculous. It is also to be pointed out that the extinct quagga, the representative of this genus in Cape Colony, was of a dull brownish grey, with a few darker bands in limited regions. Yet the quagga lived in a country identical, as far as opportunities for concealment go, with that inhabited by the zebras, and both animals had to contend with the same beasts of prey. Clearly, then, both species cannot be protectively coloured; the quagga may have been unobtrusive, but the zebra in its present state and surroundings certainly is not. It must be confessed that the advantage to the latter of a bold coat is not easy to indicate; there is a strong ground for believing that the zebra is a more archaic form than the much less conspicuous quagga, and it may be that his stripes were evolved under conditions widely different from those which now prevail. On the other hand, his staring coat is probably of little, if any, disadvantage, for the zebra is not subject to the attack of any carnivore which hunts by sight, man alone excepted. It is, however, of great value to record that which is inexplicable, provided the observer is competent and trustworthy. To discard an observation because it clashes with deductions from an hypothesis is unscientific, and the protest of an authority like Mr. Selous may perhaps carry weight in quarters where that of the casual sportsman has been hitherto disregarded.

Dr. Wallace himself has called attention to the coloration of the giraffe, and no doubt in certain surroundings this animal is less conspicuous than might be supposed. Yet it is often found in the open, and its chief haunt is thin scrub, in which it is visible at very considerable distances. A remarkable photograph was published a few years ago of a giraffe among mimosa thorn trees, but Mr. Selous believes that it conveys to some extent a wrong impression, and that the animal in question did not really harmonise in colour with its surroundings to the extent shown by the camera. Beside that, it is to be remembered that lions attack giraffes only rarely, and then by night; and that most of the habitat of the latter animals is far too dry for any carnivora to exist in. This is, of course, no proof that the blotches of the giraffe were not originally developed as a protection; but it does show that if that was so the coloration alone proved inefficient, for the species was forced to emigrate to semi-desert surroundings.

So much studied has been the subject of protective coloration that the importance of scent has been neglected. There is no doubt that the great majority of the carnivora hunt by night, and rely but little on sight to track down their victims; and the hunted are also warned chiefly by their noses of approaching danger. The value for protective purposes at night of any given coloration depends very largely on the state of the moon; a dress which blends well with the environment during the day may do the same well enough at full moon, and yet be useless a fortnight later. It was common experience in the South African war that on overcast or moonless nights the nearly black army great-coat made a picquet sentry invisible at a distance of a few feet. In strong moonlight this garb could be seen at a great distance, whereas a khaki pea-jacket, useless on a dark night, answered the requirement of invisibility very well. Similarly the dull buff and greyish tints of so many African antelopes cannot be protective at all phases of the moon; and if the dark colour of the buffalo and the sable antelope protects them in pitch darkness, it cannot have the same effect in brilliant moonlight. Mr. Selous says that if any animal needed protective coloration on hypothetical grounds, it was the buffalo, which until the advent of man and of the rinderpest formed the favourite food of the lion, yet existed in enormous numbers. This unenviable distinction is now conferred on the zebra, which, like the buffalo, emits a very strong and distinctive scent.

Another very widely current suggestion is that the deep black and dusty grey of the cock and hen ostrich respectively are both essentially protective colours, and it is adduced in proof of this, that the cock incubates during the night and his partner during the day. Consistently with this protective colour hypothesis, it should be proved that the hen relieves the cock at moonrise, which is in actual experience not the case; nor is it even absolutely true that the hen sits all day, for she gives up her post an hour or two before sunset, and does not resume it until a similar period after sun-

rise, so that the conspicuous cock thus sits just at those times of dawn and dusk when any carnivora which hunt by sight are especially dangerous.

To connect the white winter dress of many Arctic animals with their snow-covered habitat seems inevitable. But it is essential to bear also in mind that in the long Polar night, sight must be subordinate entirely to smell in the chase, especially as some of the hunted species burrow beneath the snow. That this is so, is supported by observations from sub-Arctic Canada, in parts of which some animals assume white coats in winter while others do not, without material upset of the balance in the struggle for existence. In many cases a colour which must be conspicuous against the snow places its owner, whether eater or eaten, at no especial disadvantage so far as can be ascertained. It is conceivable that in these regions the carnivora once hunted mainly by sight, and that in consequence of their prey turning white in winter they were at such disadvantage, even after following suit, that they were compelled to resort to increased olfactory development in compensation. That is a pure speculation which may have no foundation in fact, but it may explain the conflict of inferences as to protective coloration in snow-bound regions.

It should not be forgotten that the changes impressed on a species by natural selection are extraordinarily slow and correspondingly enduring. A marked excess of any quality is interpreted as a response to some environing condition which has lasted unchanged through long ages, but need not now exist. Mr. Selous has never seen birds attempting to catch butterflies in the African forests, and he concludes that protective coloration, because unnecessary, is impossible in these insects. Even the wonderful *Precis artaxia*, which when at rest with closed wings, mimics a dead leaf, actually to the extent of stalk and veins, is not admitted to be thus metamorphosed in self-defence. But this butterfly may not always have been so immune as it now is from attack; it may be that *Precis artaxia* outwitted its enemies so successfully that they finally perished of starvation and are now extinct, though the supposition that this result was brought about by some other change in the bird environment is perhaps less fantastic. However, in what seems at first sight such an exceptionally clear case of protective mimicry it is of great interest to be informed of this butterfly's present immunity from persecution.

But Mr. Selous takes a step further beyond his important and convincing criticisms of a few incorrect statements of fact. He might well have been content with proving that certain inferences and arguments held to demonstrate protective coloration in certain animals are based on misconceptions, and with leaving alone the very difficult question as to what end, if not a protective one, these colorations now serve. He has not been thus content, but supplies his own explanation of the points in issue. He writes:—

> "I would suggest that in addition to the influence exerted in the evolution of colour in living organisms by the action of sexual selection and the necessity for protection against enemies, a third factor has also been at work, which I will call the influence of environment."

This influence is held to act in some undefined way by assimilating the colour of all species resident in a locality to the prevailing hues of nature therein. In support of this it is advanced that in hot, dry regions where the general tone of the landscape is uniform all through the year many animals tend towards dull grey coloration, undiversified by bands and other markings which may characterise allied varieties elsewhere. That this uniformity is not protective is rendered probable by the open nature of the dry semi-deserts quoted as examples of such landscapes, and it is attributed to the "constant exposure to strong sunlight on treeless plains."

Now, that the quantity and quality of light in which any living creature exists may influence its appearance and its life processes cannot be disputed, but that a harmony of coloration may arise from the direct influence of a landscape on its denizens, independently of natural selection, is a proposition to which there are more objections than one. Such harmony is palpably non-existent in numberless instances; man, for instance, varies in hue from light brown to coal black in tropical Africa, yet he is there much more exposed both to sunlight and to a light-coloured environment than in countries where he must clothe himself and where grey skies and dark landscapes abound. Nor is it universal even in the karoos of the Cape Colony, selected as the very type of a constant coloured terrain: Mr. Selous excepts the cock ostrich alone, on whom sexual selection may be allowed to have exercised a predominant influence; but the baboon is also a typical and surviving denizen who has certainly escaped this influence of environment. In similar open sandy plains further north, the dark wildebeest and wart-hog are prominent amidst animals which are for the most part of fulvous or dusty shades. It is not explained how the harmony comes about, nor by what means the influence operates. The striking contrasts of conspicuous colours of the now rare bontebok make it impossible for Mr. Selous to believe that this animal is protectively coloured. So far he may or may not be right, but he would have us believe that the pure white, purple lilac, and rich brown sections of the bontebok's hide are imitations of the snow on the mountains, the deep blue of the sea, and the luxuriant carpet of wild flowers, all of which are constant factors in the landscape of the district where this animal is found. This explanation is difficult enough to accept, but there is a much more cogent reason for rejecting it than its apparent extravagance.

It will be remarked that this assimilative influence is not alleged or shown to be of any intrinsic value to those whom it affects. It is also evident that colour thus developed is essentially an acquired character, and therefore, as is believed, will not be handed on by heredity to the succeeding generation. Hence it would be expected that the newly-born or unborn young might in many cases display coloration totally different from that acquired by their parents; that, in a word, the species would breed true to their original characters. The corollary to this is that if the environment of such newly-born animals is artificially changed, as by the intervention of man, the resulting adult colorations must also be changed. There is no warrant for the latter in actual experience, and even the instances of the former case can always be explained by embryologists on the theory of natural selection. To suppose also that the thousands of separate instances of this occult influence, daily taking effect on thousands of individuals of the same species, should produce in all cases identical results is to suppose a series of coincidences unjustifiable save by a uniformity of scene in nature such as does not exist. To argue that the plentiful

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stripes and spots of the bush-bucks of Mashunaland are directly caused by the play of sunlight on their bodies through thin bush is not illogical, even if it is difficult to comprehend; but to argue in the same breath that the similar markings on the fœtal young of the situtunga, which become lost as the adults grow up amidst greyish green reedy surroundings, prove the common ancestry of the two species is to assume tacitly the hereditary transmission of acquired characters, and to give away the whole case for the previous statement. This assumption concerning acquired qualities, as has been said, is one not generally admitted, and until it is demonstrated to be at least possible it will not be easy to credit the direct influence of environment with the powers claimed for it. However grateful naturalists must be to Mr. Selous for his close and careful observations and his candour in recording them, this alternative hypothesis of animal coloration is quite impossible of acceptance in its present form. It is better to be content with a confession of ignorance about the significance of the coloration of sundry animals, or to conjecture that their present surroundings may differ from those in which the colours were evolved; it is better to do this than either to invent far-fetched and illusory hypotheses of protection, or to adopt as a refuge from them a principle for which the evidence is so meagre, and whose intrinsic difficulties are increased by the fact that it necessitates the adoption of the transmissibility of acquired characters.

Measuring Time taken in Conversion of Thought into Action.

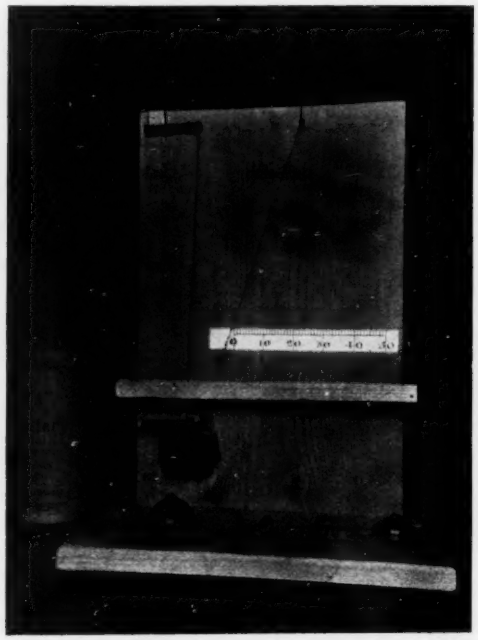
By G. G. BLAKE.

THE accompanying illustration gives a front view of the new electrical instrument for measuring time taken in converting thought into action. (Fig. 1.) It consists of a wooden board A, fastened at right angles to the centre of a second board C, which acts as a stand. A length of fine black thread with a weight W at one end of it is attached to a small screw-eye K, the thread being of such a length that when allowed to swing like a pendulum in front of the scale Y it takes just half, or some definite fraction of, a second to swing from one end of the scale to the other. R represents a small screen pivoted at its centre.

The weight W rests on the end of the small lever L, and D is a light wooden frame pivoted at X and X′

When the frame is in the position shown in Fig. 1 there is ample room for the thread K W to swing freely between it and the scale Y, but if pressed at the back, it at once tilts up, and clamps the thread between its front edge and the scale Y. T and T′ (Figs. 1 and 2) are terminals for connection to battery; P an electric bell push; S a switch connecting up an electric bell F; M a small electro-magnet, similar to those used in electric bells; I a small indicator consisting of a small square piece of white cardboard on the end of the short lever arm V, the end of which is attached by a fine thread to a screw-eye E. The lever L being pivoted at O (Fig. 2) is thus kept in position by the weight N, which presses it against the stop S. Fig. 2 also shows the electrical connections to battery B.

To measure the time taken, after seeing an object, before an action can be performed the apparatus is used in the following manner. The subject of the experiment is asked to stand at the back of the board A, and to place his hand lightly on the frame D, next he is told to look intently at the right hand top corner



Photograph of Instrument.

of the board, and the moment he sees the white card of the indicator above the top he is to press heavily

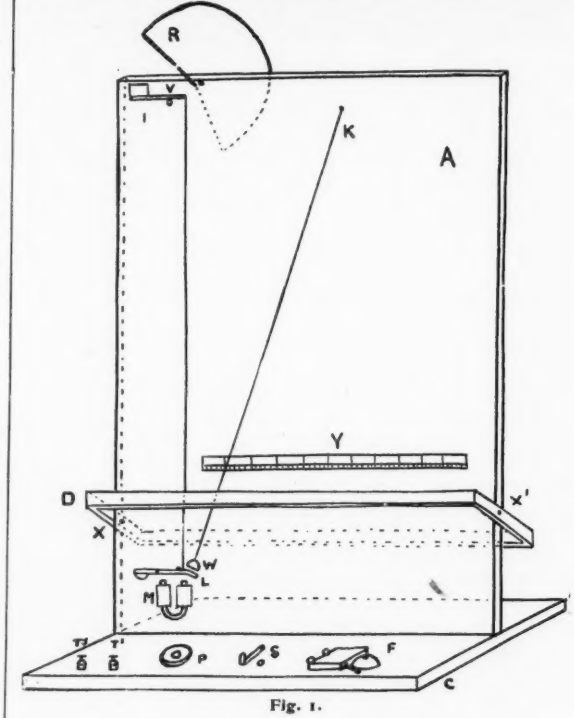


Fig. 1.

on the frame, and to keep it pressed tightly. The operator then presses the electric bell push, thus

causing the electro-magnet to attract the lever L and liberates the weight W, which commences to swing across the scale Y, at the same instant the indicator I appears above the board, and is seen by the subject, who presses on the frame D, and so clamps the thread against the scale.

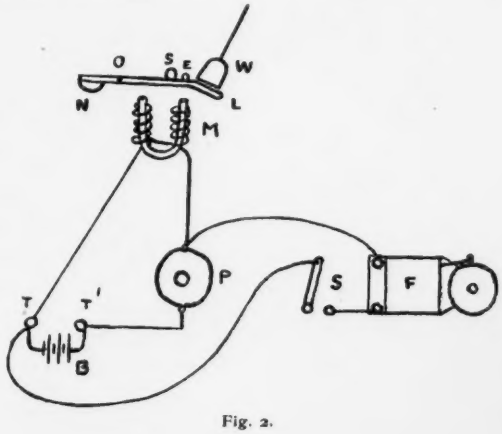


Fig. 2.

It naturally takes the subject a certain time before the sensation of sight can travel to his brain, and then yet more time before he can turn thought into action, and press down the lever. In the meanwhile the thread K W will have travelled along the scale before the lever clamps it. The distance registered on the scale represents the time in fractions of a second taken for the thought to be conceived and converted into action.

Whilst performing the test of quickness of hearing and the next experiment the screen R is twisted round, thus preventing the subject at back of the screen from seeing the indicator. The electric bell is then connected up by means of the switch S, and the subject is told to press the lever as soon as he hears it ring, and the time it has taken him to collect his thoughts and act is shown by the distance the thread has moved across the scale, as in the last experiment.

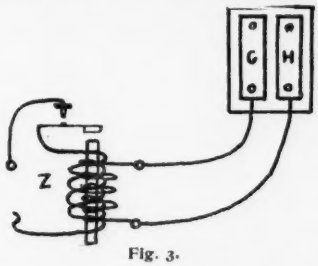


Fig. 3.

To test the speed of feeling the electric bell F is disconnected, and its place taken by a small medical coil Z (Fig. 3), and G and H, two small brass plates, are screwed to a board, and connected to the secondary terminals of the coil, in place of the usual brass handles. The board is placed behind the apparatus, and the subject places his left hand across the plates, while his right hand rests on the frame D, and he is told to press down the frame as soon as he feels a shock.

If these experiments are carried out with a number of different persons as subjects, it is surprising to note how much longer some people take than others, and that where one can act most quickly from sight another will do so much better from hearing or feeling.

Studies in Marine Life Hydroid Zoophtes.

By G. E. BULLEN.

To the student of marine invertebrate biology there is, perhaps, no other group of lowly organisms which present a greater variety of exquisite forms or offer more bionomic interest than do the Hydroid Zoophytes with their offspring the Hydromedusæ or jellyfishes.

Hidden within the dark recesses of rock pools, and discarded in bunches from the fisherman's trawl, are to be found numerous examples, which rival in beauty of form, if not always colour, the choicest blossoms of a hothouse.

It is needless to remark, however, that it is not until the microscope is brought into use that the delicate structure of these "flower animals" is revealed. For

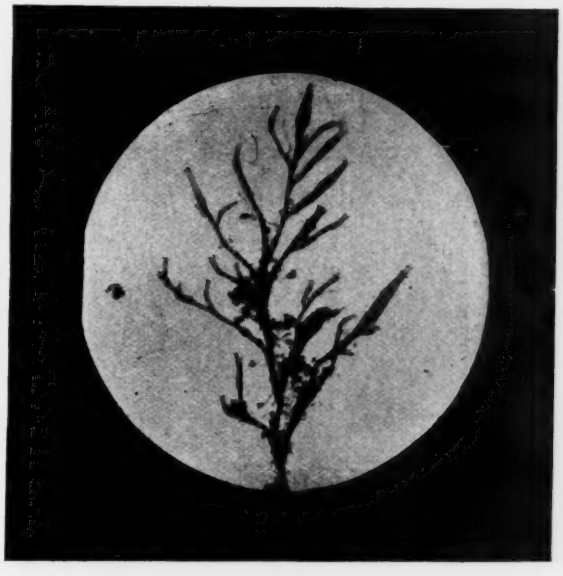


Fig. 1.—A colony of zoophytes (Bourgainvillia), microphotograph × 10

the various common species which are to be met with on any sandy beach amongst seaweed and other *débris* appear at first-sight to be of no particular interest. These, however, as a rule, are but the mere skeletons of former living colonies, and to view them in all their beauty the naturalist's dredge must be employed, or for certain littoral species diligent search should be made in the rock pools. Often these latter are so completely covered with foreign matter—algæ, diatoms, protista, etc.—that they are indistinguishable to any but the most practised eye. A specimen of this description, *Bourgainvillia ramosa*, is shown in Fig. 1, which has been sufficiently enlarged to show a certain amount of the investing matter.

In order to understand something of the habits of "hydroids," it is necessary to investigate their structure, and the following microphotographs have been taken from specimens exhibiting certain particular morphological characters.

In Fig. 2 is seen an example of a hydroid, *Clava multicomis*, in a simple form nearly approaching the text-book type, *Hydra viridis*. Here it will be seen that

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the "head" is furnished with a number of cylindrical tentacles similar somewhat to those of a Sea Anemone.

These are the means by which the animal procures its food. This consists of animalculæ often of a fair size, microscopically speaking, for these creatures have an insatiable appetite and prey upon anything which comes in their way and is minute enough for them to swallow whole.

The tentacles themselves are, indeed, formidable "breadwinners." They are, more or less, hollow throughout their length, and the outer skin is studded thickly with minute cavities. Within each of these "thread cells," as they are called, is contained a formidable battery of minute darts or harpoons, each attached to the side of the cell by a long, slender thread.

When some unwary victim happens to come in contact with one of the outspread tentacles, the darts are instantly expelled from the cells and enter the unfortunate's body, completely paralysing it. It is then drawn by means of the thread towards the tentacle

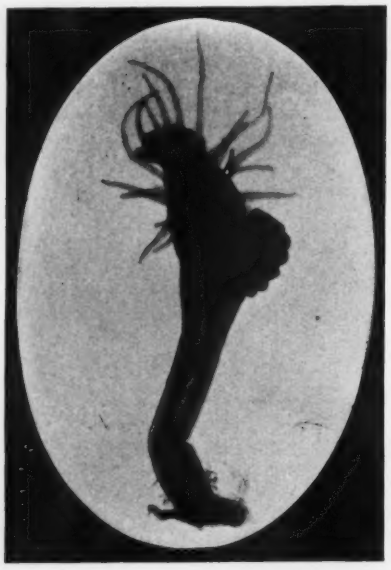

Fig. 2.—Single individual of the club zoophyte (Clava), much enlarged microphotograph.

which, in turn, passes it toward the mouth, situated in the centre of the flower-like head. The arrangement of these thread cells on the tentacles of another species, *Coryne vaginata*, common in many rock pools, is well seen in the next illustration (Fig. 6). Returning to our original example, however, it may be mentioned that the body consists throughout of two principal layers of *chitin*, the *ectoderm*, and *endoderm*; a third middle layer, the *mesoderm*, is recognised by histologists, but no reference will be made to it in the present description. When the food is passed into the body cavity of the hydroid it is rapidly digested, and by a number of vibratile cirri by which the *endoderm* is furnished the digestible and alimentary matter is circulated throughout the entire colony; the rejectamenta are expelled from the mouth. The word "colony" has been used, for, in the majority of species, the animal does not remain solitary, but by sending out roots from the base, the *stolons*, or by branching in its upward growth develops into numerous "heads" or *polypites*, each provided with a crown of tentacles, a condition which is shown in certain of the illustrations.

It is, however, in the propagation of a certain form over a wider area that the hydroid offers the greatest interest. This brings us to a consideration of the second important aspect of the zoophytes' morphological economy, viz., the reproductive system. In the

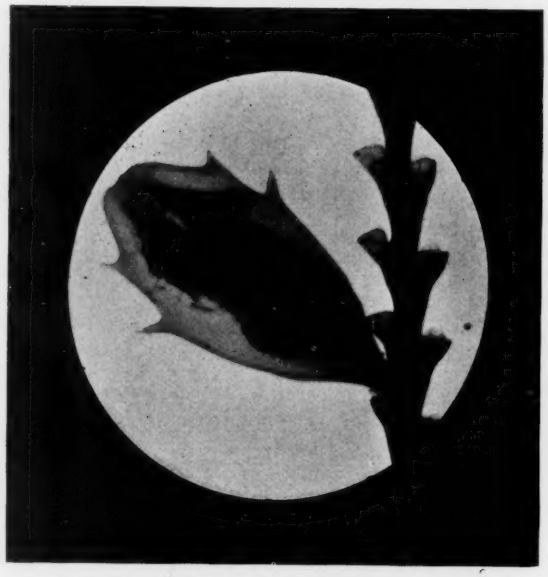

Fig. 3.—Embryo capsule of zoophyte (Diphasia), much enlarged.

majority of cases propagation consists in the liberation of free swimming embryos, either as *medusa* (*i.e.*, jelly-fishes), or, in another form, termed *planulæ*. In Fig. 7 is shown a number of undeveloped embryos still at-

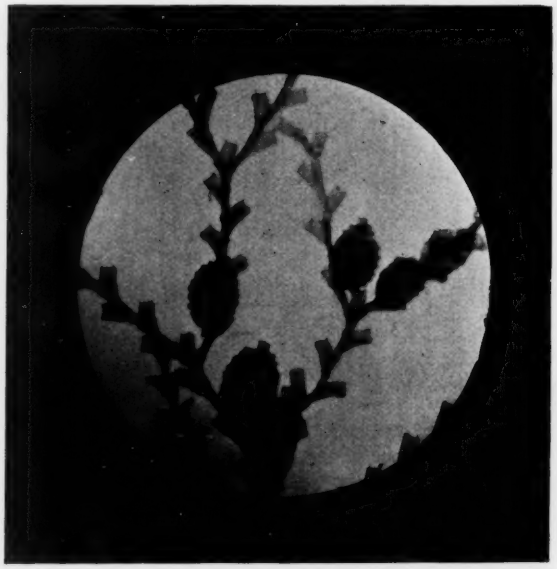

Fig. 4.—Portion of zoophyte (Sertularella), much enlarged, showing embryo capsules.

tached to the parent stock. Before these were developed the several heads presented an appearance somewhat similar to that seen in Fig. 6, but during the growth of these *gourds*, as they are termed, the tentacles atrophied. The body cavity and alimentary system being common

Marine Life Microphotographs.

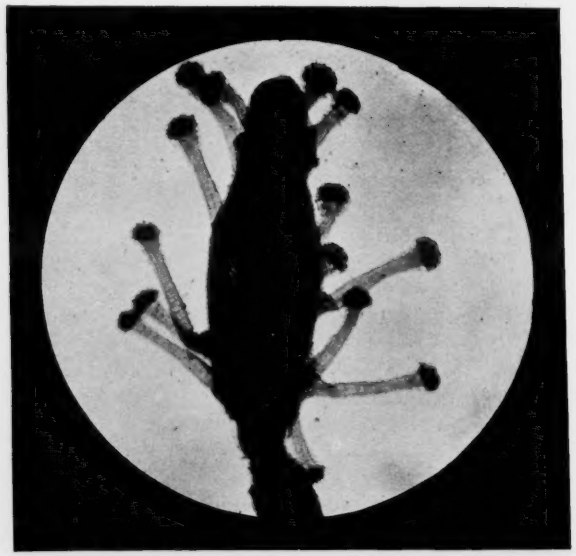

Fig. 6.—Polypite (Coryne), much enlarged to show thread cells.

Fig. 7.—Polypites (Syncoryne), much enlarged to show attached embryos.

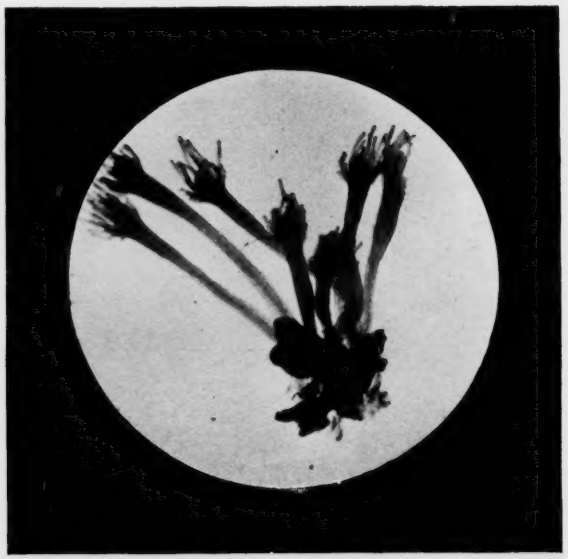

Fig. 8.—A small colony of zoophytes (Hydractinia), much enlarged.

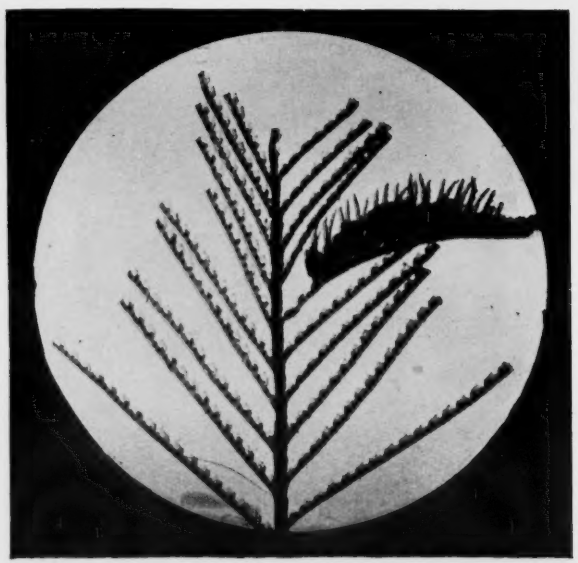

Fig. 9.—Part of zoophyte (Aglaophenia), much enlarged, showing corbula.

Fig. 10.—Small colony of zoophytes (Clytia), much enlarged, showing the calycles.

Fig. 11.—Portion of zoophyte (Gonothyræa), much enlarged, showing embryos attached to top of capsules.

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to the entire colony, nutrition to these developing embryos is derived from the labours of other *polypites*, still furnished with tentacles.

The classification of the Hydroid Zoophytes is based largely upon the form presented by the *caenosarc* or the hard chitinous *ectoderm*. Those in which the flower-like heads, or *polypites*, and developing embryos are protected by special growths of this substance, to form *calycles*, or cups, and *embryo capsules*, are termed the *Thecaphora*, in contradistinction to the *Athecata*, in which this protection is lacking.

The types hitherto touched upon, together with that interesting species, *Hydractinia echinata* (Fig. 8), which lack of space forbids us to describe, belong to this latter group. In the other main division the elegant cup-like expansions of the *caenosarc*, to form protection for the fragile *polypites*, and the highly ornate form of the urn-like embryo capsules, add considerably to the exquisite beauty of these interesting organisms.

The *calycles* are to be seen in the illustration (Fig.10) depicting a small colony of *Clytia Johnstoni* having the polypites themselves contracted.

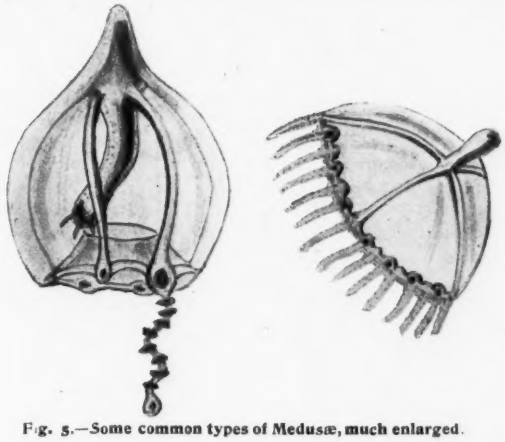

Fig. 5.—Some common types of Medusæ, much enlarged.

These appendages may either be borne upon ringed stems, which allow a certain degree of free movement, or else they are supported in rows upon the branches of the colony. In this style of growth there is much diversity in arrangement in different forms. Sometimes the cups are distributed in regular alternate intervals on each side of the stem (as in Figs. 3 and 4); less frequently on one side of the branch only (Fig. 9) in the same plane; and in a few forms they are closely clustered with the lips of the cup pointing in alternate directions. In certain types there is a jointed lid to the top of the embryo capsule and calycle, which affords perfect protection to the animal within.

The capsules show a still wider variety of forms, each more or less elegant, and suggestive of ancient Greek vases. A fair example of the less ornate type is shown in Fig. 3, the capsule of a species of *Diphasia*, and in the following illustration (Fig. 4) are seen several *in situ* upon the branches of the colony of another kind, *Sertularella tricuspidata*. An entirely different form of embryo case—it can scarcely be termed capsule—exists in all species of the germs *Aglaophenia*, an example of which is shown in Fig. 9. This is termed the *corbula*, within the wide ribs of which the developing young are contained in a thin enveloping sac.

The early life and growth of the liberated medusa is too deep a subject to be discussed even superficially here. Certain forms are shown in the next illustration (Fig. 5). It may be mentioned, however, that, despite the apparent total dissimilarity of form presented by these embryos from the parent hydroid, a certain analogy exists between them in several morphological characters.

Medusæ, in common with hydroid colonies, are highly phosphorescent. On a dark night, when these creatures are plentiful, the sea often appears to be lit up with a myriad of tiny stars. Wherever sudden disturbance occurs, such as the rapid passing of a shoal of drift fish across the bows of an approaching vessel, the sea fairly glares with luminosity. In a few forms, however, the embryo is never freed from the capsule, but remains attached to the top of the rim throughout its existence. An instance of this is shown in Fig. 11, a specimen of *Gonothyræa loveni*, where two, three, and even four embryos are shown crowded together outside with more to follow within the capsule.

In conclusion it may be said that we have discanted more upon the beauty of these "flowers of the sea" than their representation by microphotographs justify. This is, perhaps, only too true; yet it should be remembered that there can be no comparison between fresh living specimens and those prepared, however carefully, for microscopic examination.

Recent Progress with the X-Rays.

By G. W. C. KAYE, B.A., D.Sc.

THE past year or two has seen a considerable addition to our knowledge of the Röntgen rays and their associated phenomena. Professor Röntgen discovered in 1895 that when cathode rays impinge on solid obstacles the now famous rays which bear his name are generated. Their remarkable penetrating powers created a sensation in the scientific world, imagination was given loose play, and almost everyone of the many workers who sprang up on all sides prepared to assist in the genesis of the "new Physics" had his own conception of the nature of the rays.

Röntgen at first considered the rays to be longitudinal vibrations in the ether; Jaumann modified this conception and added a transverse component; Goldhammer and others preferred to regard the new rays as extremely short transverse vibrations akin to light waves; Stokes, in 1897, put forward a theory of irregular pulses in the ether; Michelson suggested their identity with ether vortices. Lastly many physicists, including Röntgen himself, were at one time inclined to the view that the rays are flights of material particles differing only from cathode rays in the absence of an electric charge. One by one most of these theories were abandoned as experiment yielded discriminating results, until at the present time we are left with the ether-pulse theory of Stokes, which, modified and elaborated by Sir J. J. Thomson, has received almost universal acceptance, and the "neutral pair" theory to which Professor Bragg has recently given his support.

It was soon found by many workers (Röntgen, Campbell-Swinton, Ròiti, Kaufmann, Sir Oliver Lodge, and S. P. Thompson among others) that the heavier metals make the most efficient targets or anticathodes for the cathode rays to impinge upon in a Röntgen ray tube. Platinum has been generally used for the purpose; at any rate, for the better class of tubes. Recently thorium, iridium, tungsten, and tantalum have been employed with entirely satisfactory results. Their high melting points give them an advantage in these days of

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focus bulbs. (Pt 1,750°; Ir 2,250°; W 3,080°; Ta 2,910° C.)

Kaye (1908) has examined the behaviour of some twenty elements when used as anticathodes in a discharge tube. He has shown that the intensity or quantity of the harder or more penetrating rays is very approximately proportional to the atomic weight of the element, the conditions, of course, being the same throughout. Fig. 1 illustrates the relation graphically over a region extending from carbon to bismuth. As to the quality or penetrating powers of the rays from the different elements there is little to choose between them.

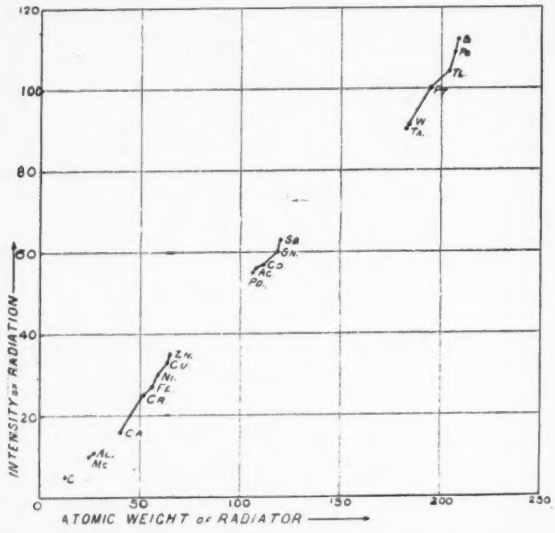

Fig. 1.

This simple atomic weight relation between intensity and atomic weight does not hold when we are dealing with the softest X-rays. The metals of the chromium-zinc group (*i.e.*, Cr, Mn, Fe, Ni, Co, Cu, and Zn) emit radiations very rich in soft rays, and, if only on the score of expense, may well be employed in many cases, as, indeed, some of them are in the cheaper tubes, with or without a thin coating of platinum. Most of these metals have, too, the advantage of high melting points (*e.g.*, Cr 1,490°; Mn 1,200°; Fe 1,500°; Ni 1,430°; Co 1,460°; Cu 1,084° C.).

It is interesting to note that, contrary to what was formerly believed, the rays from a focus bulb are not uniformly distributed. The region of maximum intensity is situated at about 60° from the normal to the anticathode, in a plane containing the normal and the incident beam of cathode rays. In this plane the intensity falls off, roughly speaking, by a cosine law.

The chief defect of the induction coil from the point of view of the X-rays worker is that it does not give pure unidirectional currents; the harmful reverse currents at "make" can, however, be suppressed in the Röntgen tube by joining it in series with one or more rectifiers or valve-tubes. Of these there is a number on the market: that first introduced by Villard and since modified by Sir Oliver Lodge consists of an exhausted tube with a large spiral cathode and a small narrowly-enclosed anode.

To Villard also we are indebted for the "osmo-regulator," a device nowadays almost always employed to meet the "hardening" or lowering of the pressure which accompanies the continued running of a discharge tube. The regulator consists of a small platinum tube, sealed into the X-ray bulb, and closed at its outer end: its inner open end is in communication with the interior of the bulb. On applying a small flame to the extremity of the platinum tube, hydrogen diffuses into the bulb, and thus the degree of vacuum can be regulated to a nicety.

The vibrating hammer interrupter fitted to induction coils has, owing to the demand for short exposures, practically fallen into disuse for medical work. A great variety of motor-driven interrupters have been contrived, many of them employing a mercury jet operated centrifugally in methylated spirit, paraffin, or compressed coal gas. For heavy hospital work, induction coils and Wehnelt interrupters have lately been constructed to work at large amperages for use directly on direct-current supply mains at potentials up to 200 volts. With an alternating-current supply no interrupter is necessary, but some form of rectifier (*e.g.*, the synchronous mercury-jet interrupter, the modified Wehnelt interrupter, the aluminium rectifiers, etc.) is inserted in the primary circuit which will transmit only one phase of the alternating current. The coil is thus used merely as a step-up transformer, and in the secondary circuit the Köntgen tube is shunted with a high-potential rectifier arranged so as to provide an easy path for those impulses which are in the wrong direction.

The output of an X-ray tube has to be specified from the standpoints of both intensity and hardness. A rough notion of the intensity may be obtained by measuring with a milliammeter or thermo-galvanometer the actual current passing through the tube. But in practice the usual methods for measuring intensity depend on one or other of the properties of the rays—ionisation, heating, fluorescing, photographic, or chemical. Owing to the delicacy and convenience of ionisation methods, most recent workers have taken advantage of this property of the rays. The heating effects are small, and require sensitive detectors such as bolometers or radiomicrometers. In medicine various chemical reactions brought about by the rays have been suggested and employed as aids to dosage; for instance, the discoloration of various alkaline salts (Holzknecht, 1902), the liberation of iodine from a solution of iodoform in chloroform (Freund, Bordier, and Galimard), the darkening of a photographic plate (Kienböck), the browning of pastilles of barium platinocyanide (Sabouraud and Noiré, Bordier), and the precipitation of calomel from a mixture of ammonium oxalate and mercuric chloride solutions (Schwartz). Recently the lowering of the electrical resistance of selenium, when exposed to the rays, has also been suggested for the same purpose.

An indication of the hardness of a beam of rays is afforded by the potential difference between the terminals of the tube; this may be measured by some form of high potential electrostatic voltmeter, such as Bergonié's, capable of reading up to 100,000 volts or more. Or, failing this, the length of the alternative spark gap may be noted. In air, at atmospheric pressure, each centimetre of a spark gap between brightly polished balls is equivalent to about 28,000 volts. For general all-round photographic work a useful spark length is about 15 cms. The most accurate way of determining hardness is to measure the absorption due to a definite thickness of metal sheet (preferably of low atomic weight), or, perhaps, better to note the thickness of sheet required to reduce the intensity of the beam to half value. Among radio-

graphers Benoist's radiochromometer enjoys extensive use as a hardness measurer. It consists of a thin silver disc surrounded by a dozen aluminium sectors in order of increasing thickness. The Röntgen rays are sent through the instrument, and the observations consist merely in matching on a fluorescent screen or photographic plate the images cast by the silver disc against one of those from the aluminium plates; the

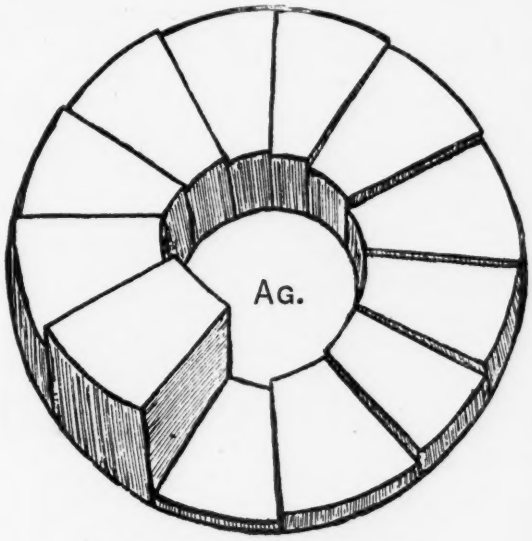

Fig. 2.—Benoist's Radiochrometer.

thickness of the matching sector increases, of course, with the hardness of the rays. The chronometer is illustrated in Fig. 2. As will be gathered, the instrument is rapid in action, but from a quantitative point of view its readings may easily be misinterpreted.

It was formerly assumed that the absorbing powers of different elements for the Röntgen rays are, roughly, proportional to their densities. However, Benoist has shown that the elements of high atomic weight are a good deal more absorbent, weight for weight, than the lighter-atomed elements. For example, to quote the results of one experiment with hard X-rays in which all the plates had equal masses and the same area, lead was 22, tin 15, and copper 8 times as absorbent as aluminium. It should, by the way, be noticed in passing that a similar relation holds for the soft γ rays from radium; for hard γ rays a density law holds, and the absorption of unit mass per unit area is a constant for all elements; in other words, these very penetrating rays altogether ignore atomic structure.

The writer has shown that when the absorbing screen and the anticathode emitting the X-rays are of the same material, the absorption is relatively low in amount; in other words, the rays are specially penetrating to such a screen. This abnormal transparency can also be detected when screen and radiator have closely adjoining atomic weights.

As is well known, the rays from a coil-driven Röntgen bulb are heterogeneous in character. The higher penetrating power of a beam after passage through a metal sheet is usually ascribed to the removal of the softer components. However, Sagnac and, later, Walter have claimed that their experiments point to an actual transformation of the incident rays by the material of the screen. Barkla (October, 1908) has put forward a somewhat similar view. In the special case when screen and anticathode are of like metal the author has shown that in general an exponential law of absorption rules, indicative of homogeneity.

When X-rays encounter matter, two kinds of what are now known as secondary rays result. One of these consists of negatively-charged electrons which are emitted from the substance with a speed of about 7 by 10^9 centimetres per second (Innes, 1907). This velocity increases a little with the hardness of the rays, but does not depend upon their intensity. More of these secondary corpuscles emerge from an element of high atomic weight than from one of low.

The other class of secondary rays is of a kindred nature to the primary. With very soft primary rays most elements (especially those of low atomic weight) emit secondary rays almost identical in quality with the primary; the secondary rays may, in fact, be regarded as so much scattered primary radiation. With hard primary rays this scattered radiation disappears and is replaced by a soft homogeneous radiation specially penetrating to and characteristic of the element which emits it. The degree of hardness of the primary rays at which this transformation begins to occur depends on the material of the radiator.

The purely scattered secondary rays show a one-sidedness or polarisation which Barkla first noticed in 1905. This, being interpreted, means that in a plane at right angles to the direction of propagation of the primary rays the secondary rays have a minimum intensity in a direction parallel to the cathode rays in the generating X-ray tube, and a maximum in a direction at right angles to this (see Fig. 3).

One may note that both classes of secondary radiation preponderate on the far side of a thin screen over the corresponding amounts which emerge from the near or "incidence" side.

Haga and Wind (1901), by allowing Röntgen rays to pass through a very narrow triangular slit on to a photographic plate, obtained broadenings of the slit image, which they attributed to diffraction. Walter

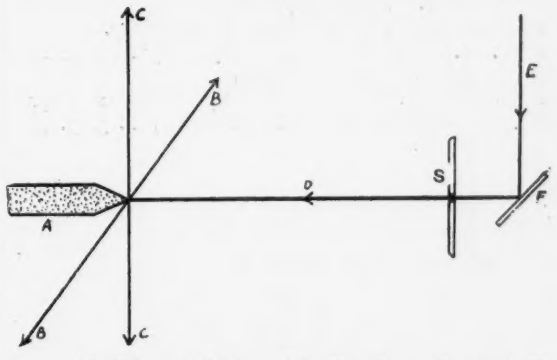

Fig. 3.—*A*—Radiator. *B*—Maximum intensity of secondary rays. *C*—Minimum intensity of secondary rays. *D*—Primary X-rays. *E*—Cathode rays. *F*—Anticathode. *S*—Slit.

and Pohl have, however, very recently shown that the extent of the broadening depends on the time of exposure, and that the diffraction of the X-rays cannot be regarded as having yet been established.

Marx, in 1906, carried out determinations of the velocity of the Röntgen rays, and arrived at the result that it is equal to the speed of light. The result would be of the greatest importance if it were substantiated,

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but after Franck and Pohl's repetition of the experiments this year we are, however, forced to conclude that Marx's measurements cannot be relied upon to furnish the value of this constant.

The present position of the X-rays is interesting on account of the difference of opinion that prevails as to their nature. The ether-pulse theory regards them as so many individual electromagnetic disturbances, which travel outwards through the ether with the speed of light whenever a charged particle has its velocity altered. In the front of each pulse are electric and magnetic forces at right angles to each other and to the direction of propagation. For a pulse to contain much energy the charged particle must be moving with a speed not far from that of light, and the alteration in its motion must be effected very suddenly.

On the neutral-pair theory the Röntgen rays consist of pairs or doublets made up of a positive and an equal negative charge, which possess rotational and a high translational velocity.

Both theories account for the penetrating abilities of the rays, their ionising properties, the lack of deviation in electric and magnetic fields, the absence of refraction, and the other special properties with which we have dealt above. A good deal of the evidence that has been called upon depends on the different results arising out of secondary radiation; it cannot, however, yet be said that any of these results are of discriminating value. Accurate indications of velocity and diffraction would be of service, as ether pulses must travel only with the speed of light; material particles could have any speed less than this. No diffraction effects could be expected on the neutral-pair theory. However, the whole question has attracted attention, and we should not have long to wait before some crucial experiments are carried out to a successful conclusion.

For a fuller treatment of these and many other associated points the reader is referred to—

Sir J. J. Thomson, "Conduction of Electricity Through Gases," 2nd edit. (Camb. Univ. Press), 1906.
N. R. Campbell, "Modern Electrical Theory" (Camb. Univ. Press), 1907.
Sir Oliver Lodge, "Electrons" (Bell), 1907.
G. W. C. Kaye, "Röntgen Rays" ("Science Progress," October, 1908).
C. G. Barkla, "On Secondary Röntgen Rays" (Juhrbuch der Rad. und Elekt., V. 3, p. 346 1908).

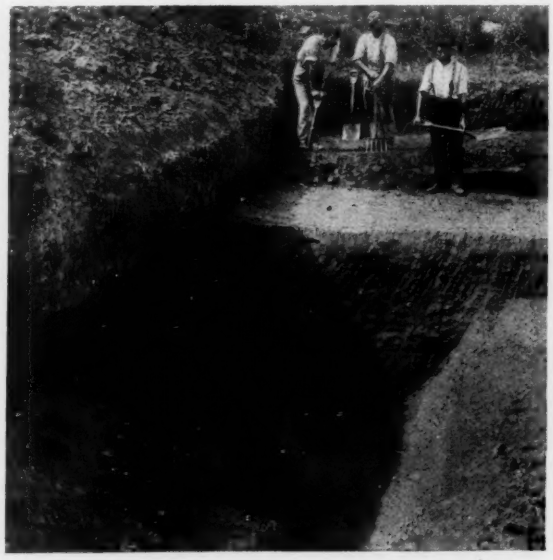
RIVISTA DI SCIENZA.—Having now reached its third year, the *Rivista di Scienza*, which is published in Bologna, and owes its value and universality to its Italian editors, Sigs. Bruni, Dionisi, Enriques, Giardina, and Rignano, is about to take a new departure. Hitherto its articles have been written variously in Italian, English, French, or German by their authors, among whom are included the names of Otswald, Solla, Claparède, Picard, G. H. Bryan, Schiaparelli, Poincaré, Boruttan, Rouse, Fabry, as well as the editors whose names have already been given; and in the two years of its career it has ably fulfilled its purpose of being an international review and summary of the progress of science in European countries. Its one drawback as an international reference summary has been that a large proportion of its readers can make themselves easily acquainted with only a part of its contents, because of the diverse languages in which the articles are written. This is to be remedied in future by appending a translation, in French, of every article, and the step has everything to commend it. The English agents for the *Rivista* are Messrs. Williams and Norgate.

Wallington, the Walled Town.

By EDWARD A. MARTIN, F.G.S.

WHERE is now the growing suburban hamlet of Wallington, in Surrey, there was in Norman times what was known to the compilers of Domesday Book as "Waleton." It has generally been supposed that the name was of Roman origin, and that the Romans established a station here, which they knew as their "walled town," or, at any rate, they found here the remains of a former Keltic entrenchment, which they utilised for their purposes and possibly extended. Manning and Bray state that the place gave its name to the Hundred in which it stood, and certain Roman remains which had been found from time to time showed that the neighbourhood was peopled by the Romans at one time.

It is certain that the name is derived from the word "vallum," the origin of our word "wall," and it has,



View of excavated ditch at Waleton.

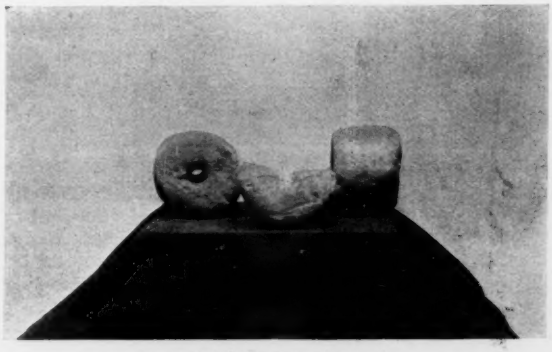
therefore, been regarded as likely that the settlement was surrounded by a vallum, whether or no the same spot had been utilised by an earlier race.

These facts give great interest to a discovery which has been recently made by Mr. N. F. Robarts, F.G.S., of the remains of an ancient vallum and ditch in the near neighbourhood, and which may well be considered to mark the identical site of the ancient settlement.

The chief light which the discovery throws upon this ancient "oppidum" is that it did actually antedate the coming of the Romans. As a matter of fact, it appears to have been used during a long period previous to the advent of the Romans, and the conclusion come to is that its founders were little removed from the Neolithic Stone Age, flint flakes being very plentiful in the bottom of the ditch, whilst, with the exception of some early coarse British pottery, most of the ware indicates late Keltic or early Iron Age work, and this is probably contemporaneous with the abandonment of the earthwork by its founders. The most recent pottery has been attributed to about the year B.C. 50, and this coincides fairly closely with the advent of the Romans in B.C. 55.

Noviomagus has been frequently alleged by anti-

quarians to have been situated in the neighbourhood of Wallington, and the name may have been given to the old Keltic settlement which they found in the neighbourhood, and which they destroyed. From the fact that no Roman remains were found by Messrs. Robarts and Collyer in the course of their excavations, it would seem that the identical spot was not actually occupied by the invaders themselves. The vallum and fosse appear to have been made around a hill at what is now known as Carshalton-on-the-Hill, and the hill selected proves to be an outlier of the Thanet Sands. The discovery was made during the excavation of the foundations of the Southern Hospital, erected by the Metropolitan Asylums Board, in what was known locally as Stag Field. The hill has an elevation of 344 feet above ordnance datum, and is not more than 200 yards in diameter. It is about a mile south from Carshalton proper, and so far as the excavators were able to trace the ditch it possibly included an area of rather over four acres.



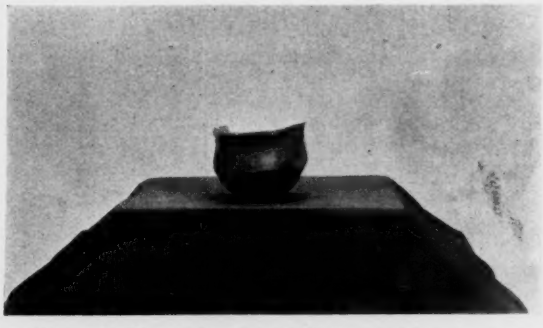
Loom-weights: size, 5 in. × 4 in.

A singular fact in connection with the vallum which must have formerly existed is that there is at the surface no sign of it whatever. All trace of it was destroyed, to a great extent apparently by the Romans, and in subsequent times by agriculture and the plough.

Four-handled drinking cup in centre; 4½ in. high, 2 in. diam. at base; mealing-stone on right front; perforated hearth-tiles (frying-pans) at back.

The excavations made by Messrs. Robarts and Collyer were at the most southerly portion of the fosse. The ditch here was found to be of a distinct V-shape, with a depth of seven feet, and a width at the top of 12 feet. No ancient remains were found in the first 18 inches of material excavated. Below this layer was found 12 to 18 inches of "redeposited clayey sand," with, at the sides of the ditch, a thin but gradually increasing layer of dark clayey sand. Then the latter thickened, and filled up the ditch for another 18 inches or 2 feet in a vertical direction, becoming darker and stiffer towards its base. In this almost all the finds were made, and the blackish stratum no doubt represents the human period of occupation, much carbonised material being found therein, showing apparently the progress of culinary operations. Further, at the base of the ditch, the V-shaped angle was filled in, almost as soon as made, by about 18 inches or 2 feet of sand, washed down probably by natural causes from the piled-up sand above, which formed the vallum. I am told by Mr. Robarts that the distinction between this sand and the undisturbed Thanet Sand below the base of the ditch was clear and distinct, and what was formerly the artificially dug bed was very apparent. In this lowest stratum bones of the wolf, horse, and ox, and flint flakes and cases were found, but its formation did not probably occupy a very long time. The fosse quickly took upon itself a saucer-shaped bottom, and its use by many human beings for probably a long period gradually brought about the dark carbonaceous layer in which most of the remains of interest have been found.

Although flint flakes were plentiful throughout all parts of the section, finished implements are reported to have been very scarce. A number of loom-weights made of baked clay were found, showing a knowledge of weaving, and also two baked clay spindle-whorls. Mealing-stones of sandstone were discovered, and in some of the cooking pots carbonised cereals were found. Most interesting of all the articles found are, perhaps, the evidence of numerous items of pottery, ranging from coarse, badly-baked specimens to finely-baked ware. It had very little ornamentation beyond what the fingers and nails would make. Attention is, however, particularly called to two specimens of pottery. One of these is a four-handled urn, or drinking cup. This was found outside the camp. The other is a large cooking vessel, with four handles, which was upon a hearth nearly at the bottom of the ditch, the handles being presumably used for supporting the vessel over the fire. A unique find was a number of perforated tiles about 10 inches by 6 inches by about ¾-inch. That these were used as hearths was proved by the discovery of a fireplace composed of them, with broken pots resting upon them.

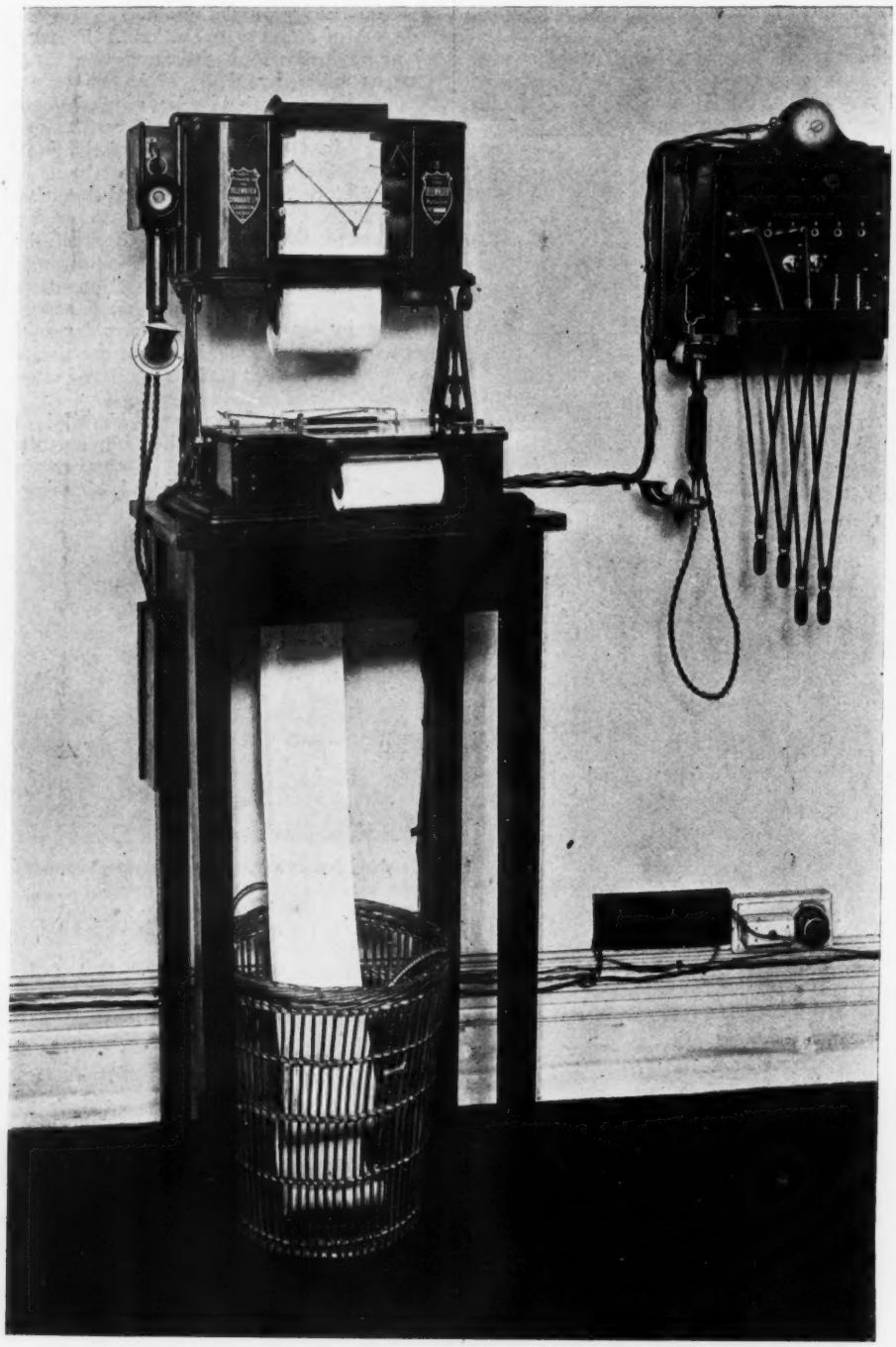


Drinking cup of fine black ware, probably imported from Auvergne.

The discovery is one of the most important that has been made in the neighbourhood of London for some years. I am indebted to Mr. Robarts for the information given, and also for the use of the photographs illustrating these notes.

The Telewriter.

IN various forms the telautagraph, the instrument for transmitting the characters of handwriting to a distance, has been known as an invention for some time. The principle has been that of attaching two jointed rods to the pen or stylus at the transmitting end of a wire; and, by the arrangement of suitable electrical connections, of transmitting electrical impulses, which are varied by the movements of the jointed rods, to the receiving end of the wire. At the receiving end the transmitted electric impulses are again transformed into movements of jointed rods, and these rods actuate a stylus or pen, which repeats identically the movements of the first pen. But the difficulties of making the instrument practicable have always been considerable. The connections have proved difficult to render either



[*Photo. Campbell-Gray.*

trustworthy or sufficiently sensitive; and while it has for several years been possible by the employment of sufficient power to transmit the impulses over short distances, an instrument which would be efficient under any conditions and over any distances has been distinctly to seek. It is found, however, in the new Telewriter, which is being developed by the Telewriter Syndicate, Craigs Court House, S.W.

In principle the Telewriter is such as we have described. In practice it is entirely trustworthy, and is so arranged that the synchronous movements of the pencil or pen can be put into operation from either end of the wire. Thus the reproductions of handwriting, figures, sketches, or any arbitrary signs can be sent backwards and forwards over any wire fitted with the instruments. The instruments, moreover, can be attached to any ordinary telephone wire, and the same battery which suffices for the transmission of telephone messages will also operate the electric impulses of the Telewriter, so that it is possible by the aid of a telephone to transmit not only spoken words, but a written message at the same time. Most verbal or telephonic messages which are not conversational have to be written down eventually. The Telewriter conveys the message and records it in one operation.

It is quite easy with this instrument to transmit messages over a telephone wire from London to Birmingham, or further, and its future usefulness in this direction is limited only by the inevitable congestion of telephonic messages which at present obtains over trunk lines. It would, however, be quite possible, and at a future date it may be quite practicable, to attach Telewriters to the ordinary instruments of the public telephone services, and thus to make written messages available over the whole network of a town's, or even a country's, telephones. At present the uses of the Telewriter are principally those which are simplified by the employment of private wires. A very large number of business firms all over the country have fitted them up between their various establishments, and between the various departments of those establishments.

An Atlas of the Moon.

WE publish with the present number of "KNOWLEDGE" the first of a series of large-sized plates of the moon. These plates are made from the magnificent photographs of the moon which are the work of MM. Lœwy and Puiseux, of the Paris Observatory, from which they have been taken by special permission. We also desire to acknowledge our indebtedness to the Royal Astronomical Society, who have been kind enough to place their photographs, together with every facility for reproducing them, at our disposal. The series of plates will number twelve in all, and, when completed, they will form an atlas of the moon. This, the first section, is a third part of the first quarter.

A New Form of Spectroscope.

By W. MARSHALL WATTS, D.Sc.

OF the various methods of measuring the positions of lines in the spectrum, all are not equally available for all purposes. The favourite plan of the optician is to use cross-wires or spider-lines in the eyepiece, in conjunction with a divided arc and vernier, or tangent micrometer-screw. For the observation of the solar spectrum, or other spectra with plenty of light, cross-wires answer well; but for general laboratory work, and in particular for the observation of faint spectra, cross-wires are of no use, from the impossibility of seeing them at the same time as the lines to be measured. Bunsen's plan of the photographed scale, reflected at the first surface of the prism (or of the first prism of a train), has been employed ever since the introduction of the spectroscope; but it is not always possible to employ a second (luminous) flame for the illumination of the scale. Various devices have been employed for special purposes. Rand Capron* seems to have been the first to employ a micrometer-screw, moving the slit-plate, in conjunction with cross-wires or a pointer in the eyepiece; and Campbell† five years later re-described the same arrangement. Campbell employed a micrometer-screw of 200 threads to the inch. To obtain accurate measurements a very exact micrometer with fine screw is necessary, on account of the very small distance of travel which will carry the slit from one end of the spectrum to the other. To avoid the difficulty—with faint spectra—of seeing the pointer or cross-wires, a phosphorescent pointer may be used, that is one coated with Balmain's paint, which is rendered sufficiently luminous to be visible for some time by burning a bit of magnesium in front of the eyepiece. This device seems to have been first employed by Vogel‡ in 1881.

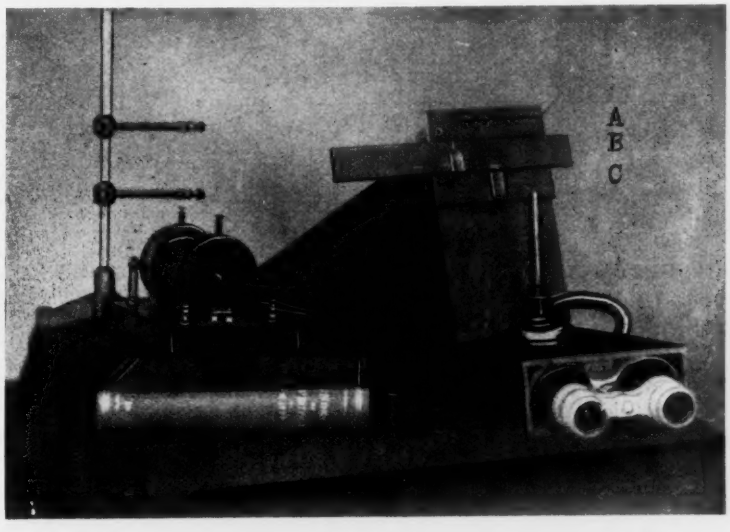


Fig. 1.

The new spectroscope, shown in Fig. 1, employs the device of a divided slit, one half fixed and the other half

* *Nature*, vi., 292 (1872). † *Nature*, xvi., 115.
‡ *Zeitschrift Instrumentk.*, I., 20.

moveable. The effect of any small displacement of the moveable half of the slit is to divide the spectrum, showing one half under the other half, so that any bright line of the spectrum, the sodium line for example, may be used as an index to measure the other lines.

This arrangement of a divided slit was first described by H. R. Procter* in 1872, and applied to a pocket spectroscope. In this, as in Campbell's arrangement, a very small motion of the slit-plate produces a very large displacement in the spectrum, necessitating an accurate micrometer-screw. In the new spectroscope now described there is this important difference from Procter's arrangement, that there being no collimator, the motion necessary to carry the sodium line as index from the violet to the red, say, from wave-length 3500 to 7500 requires a motion of the slit-plate through no less than 400 mm. The photograph shows at the lower part a binocular spectroscope through which the spectrum of the Bunsen flame is seen, the light being reflected at a plane mirror at the back of the instrument. In order to secure the exact adjustment of one millimetre of the scale to correspond to ten Ångström units, the mirror is capable of a small adjustment in distance by means of a regulating screw. The millimetre scale on which readings are taken is placed in front of the observer, and is seen in the photograph at the top of the instrument, marked A. Underneath it is the moveable slit B, and below this the fixed slit C.

Fig. 2 shows the appearance of the spectrum of the Barium flame, the lower portion having been displaced so as to make the sodium line coincide with the Barium green line at 5242; and Fig. 3 shows a portion of the Helium vacuum-tube spectrum, the sodium line from the Barium flame being used as index; it is shown coincident with the Helium line at 4713.

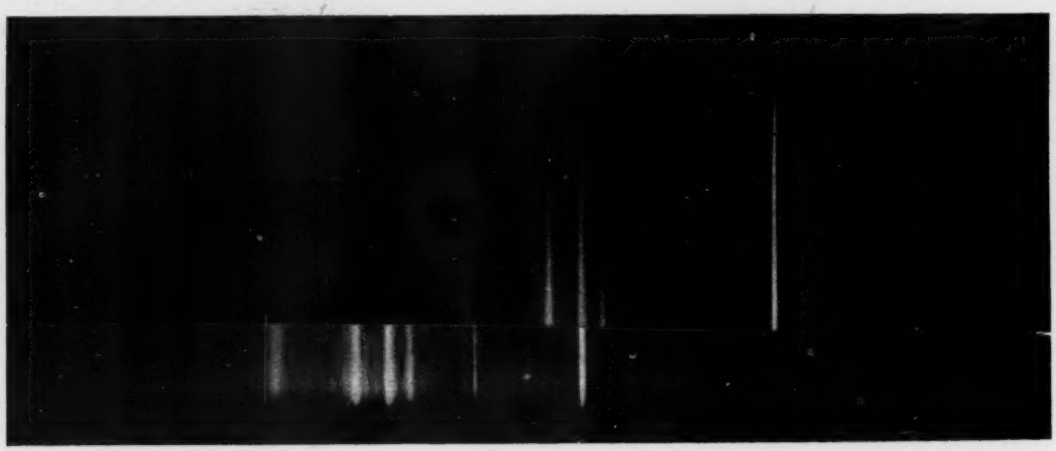


Fig. 2.

It will be observed that the flame or other source of light is conveniently within reach of the observer, and that the scale is in a convenient position to be read. In the simple form of instrument shown, the scale reads only to ten Ångström units, or by addition of a vernier to one unit; but by the employment of a micrometer-screw to one-tenth of a unit (or to one-hundredth, if required). The spectroscope being a diffraction spectroscope, the lines are spaced according to wave-length,

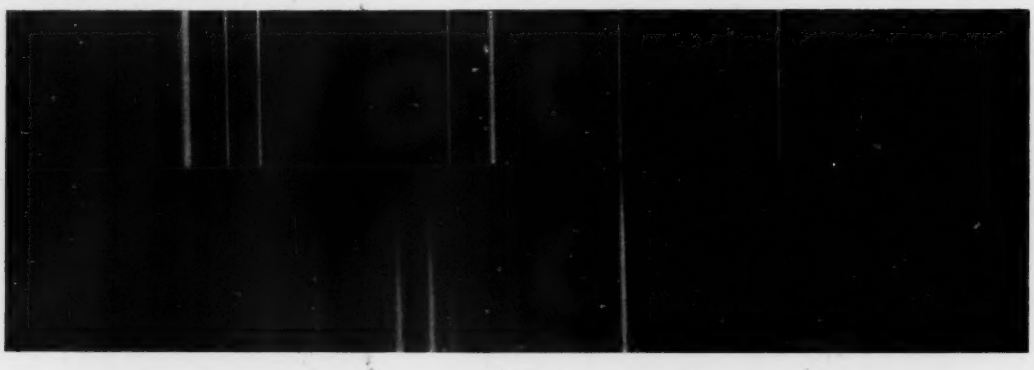


Fig. 3.

so that the scale is simply one of equal parts. If the moveable slit is much displaced from the position of the fixed slit, it must be provided with a second flame to furnish the index line. It will, of course, be understood that the width of the instrument as shown will only allow of two lines moderately close together being brought into coincidence, since, as stated above, the width would have to be greater than 400 mm. to allow a violet line of wave-length 3500 to be brought into coincidence with a red line of 7500.

* *Nature*, vi., 534.

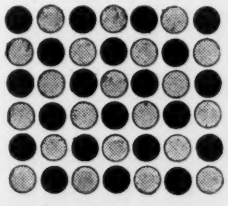
Photography: Pure and Applied.

By CHAPMAN JONES, F.I.C., F.C.S., &c.

The "Thames" Colour Plate.

After enjoying a monopoly for a little more than a year, the Autochrome plates of Messrs. Lumière have a competitor in the "Thames" colour plate, which has been on the market for two or three weeks. The general principles upon which the two plates are founded are exactly the same, but in the details of their construction they are very different. They both have a triple-coloured screen through which the exposure of the sensitive layer takes place, and in both cases the developed image is dissolved away instead of fixing to produce a negative as usual, and then the remaining silver salt is reduced to metal to form a positive image. Thus, those coloured dots that correspond to the colour of that part of the image that fell upon them are left uncovered, while the dots of the other colours that are not wanted are hidden by a deposit of silver, and the colour of the original is reproduced in the transparency with a certain measure of accuracy.

In the Autochrome plates the necessary three colours are distributed over the plate by dyeing starch granules, mixing them, and spreading a single layer of them over the surface, while in the "Thames" plate the disposition of the colours is symmetrical and regular, the red and green being put upon the plate as round dots of coloured inks, while the blue fills in the spaces between them, as shown on a considerably enlarged scale in the figure. These dots are very much larger than starch granules, but they are just small enough to be invisible to a normal unassisted eye. Indeed, the separate colours appear to me rather more visible on the Autochrome than on the "Thames" plate, because the colour unit of the former is not the single starch granule but groups of granules, for it seems impossible to thoroughly mix them. The Autochrome plate is a single plate complete in itself, but the "Thames" plate consists of two plates, the parti-coloured screen, and the sensitive plate, which are separate. They are brought together for exposure, film to film, the sensitive plate alone is taken for development, etc., and when finished and dry it is replaced upon the coloured screen by means of register marks and observation of the colours of known objects, and the two are bound together to form the transparency. The method of separate plates has the advantage that the colour screen is not lost if the sensitive plate is spoilt, and there is no risk of injury to the colour screen by the reagents used in developing, reversing, and fixing the image. On the other hand, though it is easy to place the two plates together in approximately the correct relative position for binding, I find it very difficult indeed to get them exactly right, for a microscopic examination almost always shows a want of correspondence between the developed dots and the coloured dots, so that a little of the wrong colours come through, and this practically results in diluting the colour that should be with white light. It appears that the makers intend shortly to issue a plate complete in itself. There is also the difficulty of a want of intimate contact between the two films, for although the glass used is of very excellent quality it is not possible to get the films so close as if the second were coated on to the first, and the result is that by looking through the compound plate in a slightly oblique direction, the colours are noticeably different.



One great advantage of the "Thames" plate is its rapidity; it is, perhaps, eight to twelve times as fast as the Autochrome. The emulsion is exceedingly sensitive to red light, to rather beyond Fraunhofer's line B with an ordinary exposure. Doubtless this accounts for the pure yellow compensating screen supplied to attach to the lens, while the Autochrome compensating screen is an orange-yellow, and also for the general greenish tint that the "Thames" colour-plate screen shows, while the Autochrome shows a reddish tint. Then the "Thames" colours are transparent, while the Autochrome colours are only translucent, because of the structure of the starch granules. All these conditions tend to a greater rapidity in the "Thames" plate.

The "Thames" plate, in its divided condition, as at present issued, has many advantages for experimental purposes. As it is only a few weeks old it is hardly fair to expect the same degree of perfection as can be obtained by plates that have been made by thousands and sold for more than a year. When the "Thames" plate is made in one instead of two parts, and the manufacturing details a little improved, there can be no reason for doubt that it will offer still more advantages and take its place as a permanent addition to the resources of the photographer.

Gold Deposits in Toning.

It is well not to suffer ourselves to be the slaves of theories, for however well founded they may prove to be like railway lines allowing those who travel only by their means to pass across the realm of facts, but often obliging them to neglect and sometimes to misinterpret the character of the vast area that extends in all other directions than their own. Until the survey is complete, even rival theories may co-operate in leading from the known to the unknown. The various colours that some substances may assume when deposited under slightly different conditions have often been accounted for on the assumption that the particles vary in size, and that the smaller particles, being able to oscillate more quickly than the larger, absorb light of smaller wave-length, tending, therefore, to reflect red, while the larger particles absorb light of greater wave-length and tend to reflect blue, provided, of course, that the size of the particles is suitable for showing the effects of selective absorption. It is a very old and well-known fact that gold can be deposited in either a red or a blue form, and that, under certain circumstances, retarding the deposition tends to give the red variety. If the gold toning of a silver print is too slow, a large proportion of gold may be deposited on it, but as the gold is red, the reddish colour of the print is but little modified, while a more rapid action would produce a maximum change of colour (towards blueness) with a minimum of gold. Some, for the sake of economy, endeavour to realise the latter condition, but those who aim at producing the most reliable results would seek to get the desired colour with the maximum of gold, and so ensure the production of an image less liable to change. W. Stenbing (*Ann. Physik.*, 1908, 329) finds that the colour of the gold does *not* depend on the size of the particles, which may vary considerably, but upon two distinct kinds of particles, which exhibit differences by polarized light that indicate that their difference lies in their geometric form.

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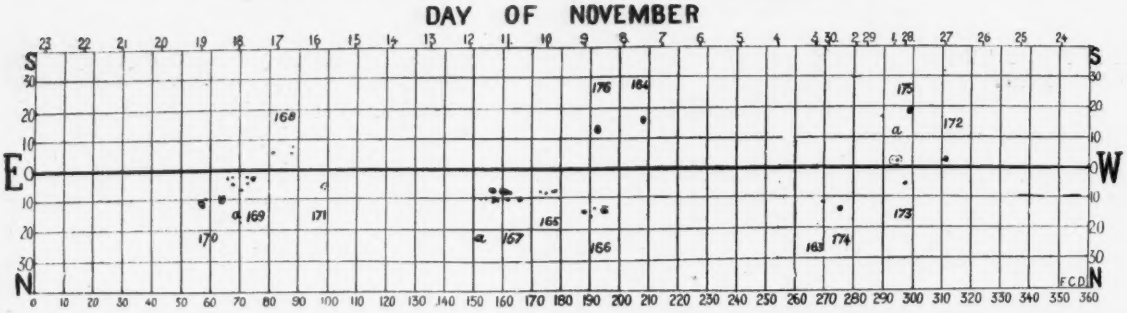
Solar Disturbances During November, 1908.



THERE was a greater amount of activity on the visible disc during November than in the preceding month. The longitude of the central meridian at noon on November 1 was 293° 30′.

No. 163 appeared in the October chart, but was visible until November 7.

No. 164.—A considerable spot near limb 2nd, increased, two umbræ 6th, and three by 9th, the spot being more elongated. On 10th the preceding end had drifted to southward, and by 12th was nearly at right angles to its original position. Only a pore on 13th. Its diameter over 16,000 miles.

No. 165.—On 5th a tiny pore formed amid brilliant faculæ, a group of seven or eight on 6th, the group increased in length, and the spotlets in size, one reaching 10,000 miles in diameter, and the length 56,000 miles. On 10th only one spot, last seen 15th.

No. 166.—A pore showed on 6th, four on 7th, enlarged on 8th. The group attained a length of 60,000 miles, the largest member being 14,000 miles across. A double spotlet 12th, only a pore when last seen 14th.

No. 167.—A few pores in brilliant facula on 6th, more conspicuous 7th, the leader a two-umbra spot 10,000 miles in diameter on 8th. On 9th its area, 82,000 × 35,000 miles, in elliptical form, and a centre of great activity. On 12th two large spots with pores between. On 13th Mr. W. F. Denning found it conspicuous to naked eye. The maxmium diameter was 43,000 miles. Last seen at limb on 17th.

No. 167*a*.—A line of three pores 30,000 miles long, 13th; one only 15th.

No. 168.—A spotlet with a group of varying pores 53,000 miles long. 12th to 17th.

No. 169.—A small spot, 9,000 miles in diameter, with pores eastward. 13th to 23rd.

No. 169*a*.—A group of pores, 30,000 miles long. 15th to 17th.

No. 170.—An elliptical group on 15th. On 17th the eastern spot, 17,000 miles in diameter. On 20th the form was that of two large two-umbra spots with pores between, the group being 60,000 miles in length. Last seen 25th at limb.

No. 171.—An oval group of five pores, 15,000 miles across, on 15th, but on 16th only one pore.

No. 172.—A spot and pore 22nd, dwindled 23rd, a pore only 25th.

No. 173.—A small spot seen only 25th and 26th.

No. 174.—Also a small spot seen only 25th and 26th.

No. 175.—A fine spot, which increased in diameter from 7,000 to 15,000 miles, two pores preceding it, the group being 74,000 miles in length, till 29th, and one hazy pore 30th. 25th to 30th, when thick, cloudy weather intervened.

No. 175*a*.—A tiny pore with grey companion following on 29th in bright faculic cloud near centre of disc, the pore remaining until 30th.

No. 176.—A spot some 15,000 miles in diameter had come round 30th, by December 7th it had changed to a triangle of spotlets. Last seen 9th, when two close spotlets had two minute pores south-east.

The chart is constructed from the combined observations of Messrs. John McHarg, Arthur Mee, and Frank C. Dennett.

CORRESPONDENCE.

Physical Constitution of the Moon.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

SIRS,—As I understand it, the theory now generally accepted by astronomers as to the formation of the mountains and so-called craters of the moon is that their formation has been the result of volcanic action, or of other forces acting from *within* the moon.

To my mind this theory has never been convincing or satisfactory, and fails to explain several of the lunar phenonema, in particular that of the bright streaks which radiate from Copernicus.

One eminent astronomer states that he does not suppose that in these days anyone believes that if we could see the back of the moon we would find any characteristic difference between the scenery there and that on the side which is turned towards the earth. To this supposition I, although only an amateur astronomer, beg to take exception, as I believe that most of the features of the scenery on the side of the moon next to the earth were put in by the impact of pieces of the earth, thrown off after the earth and moon first parted company.

To the following generally accepted theory with regard to the formation of the moon, viz., "that she was originally part of the earth, and that a partition having taken place while the materials of the earth and moon were still in a plastic state, a small portion broke away to form the moon," I would add that afterwards, and while the moon was still in a plastic state, other pieces, probably from about the cavity whence the moon escaped, broke away from the earth, sunk into the surface of the moon, and by their impact caused the formation of the ring mountains or walled plains, the larger and shallower ones without the central cones being formed first, and the smaller and deeper ones with the central cones next, and then during the ages following, while the moon was receding from the earth and the earth and moon were solidifying and cooling, other smaller pieces broke away from the earth to form other mountains and pinnacles, and last of all smaller and yet smaller particles or granules—of metals probably—when the bombardment was coming to a close were thrown off from the earth, and arranged themselves into the bright streaks which we see radiating, in lines of force from Copernicus, as from a magnetic pole of the moon.

Ring mountains on a small scale can be made by drop-

ping stones from a high elevation on to a mud bank below, and formations similar to what we see in the moon will be produced, wider and shallower and without central cones where the mud is more liquid, and narrower and deeper and with central cones where the mud is stiffer. If the stone-throwing be continued long enough, and plenty of stones be thrown down, we will find that the surface of the mud very much resembles the surface of the moon as we see it through a telescope.

Any person examining the lunar mountains, as distinguished from the ring mountains, through a powerful telescope will notice that they bear little or no resemblance to our mountains, as they appear to be piled up from the outside and not to have been the result of forces acting from within the moon, or from rock folding, as in the case of our mountain ranges. They appear to have more of a stalagmitic formation, and could be formed by pieces from the earth being attracted by, and attaching themselves to, the more prominent features of the moon.

For the foregoing reasons it appears to me more probable that the ring mountains or walled plains and the other mountains and projections which we see were formed by forces acting outside the moon than from volcanic action or other action from within.

This theory supposes that the moon proper was first thrown off the earth, and that its features, *on the side next to us* were added *gradually by a system of pelting from the earth*, and to my mind is a more satisfactory theory than that which supposes that it was thrown off in one piece, and that it received no further increments from the earth.

As the attraction of the moon at its present distance helps to produce the phenomena of tides on the earth, would it not be resasonable to suppose that its attraction when much closer to the earth would have accounted for the transfer of the solid particles which, in my opinion, have gone to make up the present physical construction of the moon?

Beer and Mädler, in "Der Mond," state that there is no trace of any present volcanic action on the moon's surface. To this I think it might safely be added that there is very little, if any, trace of past volcanic action on its surface.

Yours, etc.,
H. L. MEADOWS.

The Vegetable Caterpillar.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

SIRS,—In commenting on my letter in the August number of your magazine, your correspondent G. A. Laing, explains that he "gave the theory generally accepted" in New Zealand. Most assuredly, I did not mean to reflect in any way on his good faith. My desire was simply to correct some popular errors with regard to the life-histories of *Porina* and *Sphæria* (*Cordiceps*). I cannot, however, agree that the idea of the fungoid spores gaining an entrance through finding a lodgment in the segmental folds, and entering the caterpillar's body directly through the skin, is at all improbable. Mr. Laing points out that no trace of disease or disfigurement is to be observed on the dead caterpillar, but I do not think that this in any way tells against the theory. A microscopic spore could not be expected to leave any visible mark or rupture on the integument. If, as Mr. Laing contends, the spores are eaten by the caterpillar, then we must assume that not only are the spores resistant to the gastric juices, but capable of germinating under their action. Again, larval parasites almost invariably avoid the vital organs till the last. Now, if any fungoid growth took place in the intestinal tract, it would probably speedily cause the caterpillar's death, and thus interfere with the full development of the *Sphæria*. Though it is perhaps too much to assume that a vegetable parasite should develop the instinct of avoidance of certain parts, yet it is quite probable that, following the law of least resistance, the mycelium of the fungus should ramify through the tissues before penetrating the more important organs. The question, however, could only be settled by the examination of a series of larvæ in various stages of growth, and I am not aware that any such investigation has yet been undertaken.

Mr. Laing has been misinformed as to the fruit-stalk of the fungus always growing from the head of the caterpillar. I have seen many examples in which the stalk arose from the thoracic segments and some in which it was placed on the abdominal ones. There are also instances on record in which two or more stalks have been observed, sometimes placed near each other, and occasionally at opposite ends of the larvæ.

Regarding the attachment of the *Porina* larvæ to the *Metrosideros* ("rata" of the Maoris, "ironwood" of the colonists), that is a popular fallacy. During a residence of more than 30 years in New Zealand I have never met with the larvæ under the rata, and have several times found them in localities where the nearest rata was at least 20 miles away.

In the South Island of New Zealand the larvæ of *Porina dinodes* is the species attacked by the fungus. In the North Island, *P. signata* appears to be the host, although there is an isolated instance on record of *Hepialus virescens* being victimised.

Yours, etc.,
A. PHILPOTT.

Invercargill, New Zealand.

Halley's Comet.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

SIRS,—Among the articles and paragraphs relating to Halley's Comet which have appeared in "KNOWLEDGE," I have not noticed any statement as to whether this comet at its approaching return will be more or less favourably situated for observation than it was at the last or previous returns to perihelion. It would appear from historic records of the appearances of this comet in earlier times that—making all due allowance for the exaggeration of ancient writers—it must have been on some occasions a much more conspicuous object than at its last return in 1835. Physical changes in the comet itself may, no doubt, account for considerable diversity in its appearance at different times, but its greater apparent magnitude on some returns than others is, I suppose, largely due to its greater proximity to the earth; its position in 1456, as I have read, being exceptionally favourable, and I am prompted to enquire whether the relative positions of earth and comet in 1910 will be such as to warrant us in expecting the comet to become an unusually conspicuous object. Because of the great interest taken by the scientific world in the return of Halley's Comet, I believe that the general public has formed exaggerated anticipations as to its apparent magnitude which it might be well to correct. According to published descriptions of its appearance in 1835 it seems to have been at no time brighter than a star of the third magnitude, and its greatest visible extent of tail did not exceed 2°, which would, I suppose, compare with the appearance of Daniel's Comet of last year. If, therefore, it will approach no nearer to the earth or be no more favourably situated for observation on this occasion than it was in 1835, it is not likely to become a very conspicuous object to naked-eye observers and those who are looking for a spectacular apparition are liable to be disappointed.

I would also like to know whether any charts have yet been published tracing the apparent path of Halley's Comet among the stars from the time it is likely to come within the range of small telescopes, giving its probable position on certain dates at short intervals, and if so, where they are procurable? And further, at what time and, approximately, in what position is it likely to first become visible to the naked eye?

Yours etc.,
"CANADIAN SUBSCRIBER."

St. John, N.B., Canada.

Euclid's Definitions.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

SIRS,—The "system of logical definitions" set forth by H. Stanley Redgrove is certainly "remarkable" in a sense in which he did not expect that adjective to be applied.

In the first place, I fail to see that any good object is to

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be achieved by reversing the order of Euclid's definitions of a point, a line, a surface, a volume (*i.e.*, I presume, a solid), which seem to me not only natural, but logical, in that they proceed from the less to the greater, from no dimensions to three dimensions. How can one logically comprehend three dimensions unless one has first been introduced to one and subsequently to two?

Next, Mr. Redgrove defines a plane as "a portion of the surface of a sphere which has been increased in magnitude without limit." Now, a portion, however small, of the surface of a sphere will *always* be curved, no matter how small the sphere itself may be, so that this curved surface increased in magnitude indefinitely will be anything but a plane. If it be urged that the portion in question is a point, then how can you increase indefinitely that which has no magnitude?

Similarly, "a straight line is part of the circumference of a circle which has been increased in magnitude without limit"; as every part of the circumference of a circle is curved, the same remarks apply here as in the case of the sphere.

Finally, I would ask, "What is the use of a logical system of geometry if it cannot be taught to those who need to learn"? And while I admit that Euclid's definition of a straight line is not happy, I submit that *the* definition has yet to be found, unless one of two added in a note in my copy of Euclid will pass, viz.: "If there be two lines which cannot coincide in one point without coinciding altogether, each of them is called a straight line." Or, "a straight line is that which cannot cut another straight line in more points than one."

Yours, etc.,
"DABBLER IN GEOMETRY."

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

SIRS,—Mr. Redgrove's letter makes it plainly obvious that the modern method of inculcating the principles of elementary geometry is anything but a logical one.

Teachers of the subject might profit much by an intelligent perusal of Clifford's "The Common Sense of the Exact Sciences" (International Scientific Series), especially of Chapter II., on "Space."

The average scholar seems to commence his study of the subject with the erroneous notion (almost concept) that the geometrical point, line, and surface have equivalent dimensional value; whereas a little careful preliminary explanation should enable him to perceive that the geometrical point, line, and surface is nothing more or less than the starting or finishing point of the same or another geometrical point, line, or surface.

Mr. Redgrove's suggestion that the study of the subject might be commenced with the geometry of the sphere would seem to be not only feasible, but practicable, providing the scholars construct a sphere out of some plastic material. Thus, without the usual but perplexing definitions, let them divide the sphere into various parts and lead them to discover for themselves what they have actually done, and so attempt to make their own definitions.

Yours, etc.,
J. F. HAMMOND.

The Boomerang.

To the Editors of "KNOWLEDGE & SCIENTIFIC NEWS."

SIRS,—In my note on boomerangs, Dravidian cranial indices, etc., the 7's (sevens) have unluckily been mistaken for f's. F5 and f6 as well as f2 should read, 75, 76, 72. The numbers are from Beddoe's "Races of Britain" and Sir Herbert Risley's "The Races of India." The South European crossing of the 7 is a convenience in summing, for it prevents the confusion of 1 and 7. It did not occur to me that it might be mistaken for an f.

The correction is an important one, as the cranial indices of the less barbarous and undeveloped races approach 100.

Yours, etc.,
W. W. STRICKLAND.

ASTRONOMY.

By CHARLES P. BUTLER, A.R.C.Sc. (Lond.), F.R.P.S., F.R.A.S.

Magnetic Field in Sunspots.—Professor G. E. Hale gives a more complete account of his recent investigations of the Zeeman effect in sunspot vortices, illustrated with further photographs showing most clearly the separation of the components of the lines affected. The whole question is thoroughly discussed as far as the observations at present permit, and the points still doubtful are clearly recognised and marked for immediate investigation. The magnetic separations of the chief lines have been measured by work on spark spectra in the laboratory of the Solar Observatory, and a close agreement, considering the difference in character of the solar and terrestrial lines, is found in most cases. Some of the initial difficulties involved may be explained by the idea of centrifugal separation of the negative and positive corpuscles, the negative having the higher velocity.

Since the preliminary work Professor Hale has made over two hundred photographs of spot spectra with polarising apparatus, and these may be discussed in direct connection with the corresponding spectroheliograms showing the photospheric currents at the time. A specially interesting case is illustrated, in which two neighbouring spots near the equator, one north, the other south, are clearly shown to have vortices rotating in opposite directions, judging from the curvature of the stream lines. The spectra of these spots are also shown, and the direction of displacement always depends upon the direction of the revolution in the vortex, so that if this is found to hold, we may conclude that the field is always produced by the revolution of particles carrying charges of like sign. Other interesting results when the spots are observed near the edge of the sun, giving the emitted light at right angles to the field, are described.

A most interesting point is, that in some lines an asymmetric separation of the triplets is observed. This feature of magnetic action has been observed on terrestrial spectra by Zeeman, who investigated the phenomenon by means of a *non-uniform* magnetic field. As the field of a spot vortex may very easily vary from one section to another this would give another definite connection between the two phenomena. So far as the doublets have been observed, however, a decided tendency to constant separation has been shown, and this is one of the points needing explanation. With his characteristic energy, Professor Hale announces that he is now designing a new equipment for more powerful research, consisting of a spectrograph of 75 feet (23 metres) focal length, for use with a tower telescope of 150 feet (46 metres) focal length, with which he hopes to get observations of small spots as well as large ones, and to resolve many of the close doublets and triplets in their spectra.—(*Astrophysical Journal*, 28, pp. 315-343, November, 1908).

Graphical Method for Predicting Eclipses.—Dr. F. Schlesinger has developed a simplified method for determining the circumstances of an eclipse of the sun, which for many purposes should prove as efficient as the more cumbrous rigid analytical methods. It is evident from the records of the more recent eclipses that the eclipse data cannot be predicted with extreme accuracy, owing chiefly to uncertainties in the moon's place in its orbit, and also to a measureable degree to the varying effect of irradiation on the diameters of the sun and moon, rendering the ordinary determinations of these quantities unsuitable for computation of eclipse data. Irregularities in the moon's topography may also introduce an error of as much as two seconds in the predicted times of contact.

On examination of the expression connecting the apparent angular distance (d) between the centres of the sun and

moon at conjunction with the zenith distance and azimuth, it is shown that, as the maximum value of d in any eclipse is about 33′, or less than 0.01 of a radian, the higher terms in the expansion of the series may be neglected if neither the first nor the fourth contact occurs within 5° of the zenith; the distance between the centres of the sun and moon may then be computed by the formula

$$d^2 = \overline{\Delta Z}^2 + \overline{\Delta A}^2 \sin Z_1 \sin Z_2$$

where ΔA = diff. in azimuth, ΔZ diff. in zenith distance, Z_1 = zenith distance of centre of sun, and Z_2 = zenith distance of centre of moon.

This equation lends itself readily to graphical solution. From the eclipse charts published several years in advance in the Ephemeris estimate T_1, T_0, and T_4, the respective times of first contact, middle of eclipse, and fourth contact. For these instants compute the zenith distances and azimuths of the sun and moon. Apply parallax and compute the quantities by the above formula, and plot on scale of, say, 5″ to the millimetre. The resulting curve will seldom diverge much from a straight line. With the *sum* of the semidiameters of the sun and moon as the radius and the origin as centre describe two arcs cutting the apparent path of the moon in two points. These will correspond to the times of first and fourth contacts. Their angles of position may be laid off directly and their times obtained by interpolation. An arc described with the *difference* of semidiameters will similarly give the data for second and third contacts. Attention is drawn to the possibility of allowing for variable effect of parallax. So long as T_1, T_0 and T_4 are correct to about five minutes, the author has found that this simple process yields contact times that are within a few seconds of those obtained by rigorous methods, and the other circumstances of the eclipse with corresponding accuracy.

Water Vapour on Mars.—From quantitative measures of Mr. V. M. Slipher's spectrograms of the spectrum of Mars made with a new spectral comparator Professor F. W. Very finds that, compared with the lunar spectrum, that of Mars shows the α water vapour band 22 per cent. stronger than in our terrestrial atmosphere, while the solar C line is about equally intense.—(*Kiel Centralstelle Circular 106*, December 9, 1908.)

Double Star Parallaxes.—Professor Barnard contributes an interesting account of his recent determination of the parallax of the physical double Krueger 60. The chief star of the pair noted by Krueger has been shown by subsequent observations to be in orbital motion with a small star near by, and this led Barnard in 1900 to start a series of measures with the 40-inch telescope for determining the parallax of the chief star. The corrections for the differential expansion of the steel telescope tube, the focal length of the object-glass, and changes of the micrometer screw are shown to compensate each other to a considerable extent, and the corrections for aberration were found to be insensible. The parallax from equations of condition obtained from 76 observations of position-angle and distance is

$$\pi = + 0''.249 \pm 0''.0105.$$

This corresponds to a distance of over 830,000 times the sun's distance. Light would require 13.1 years to reach us from this star. A suggestive confirmation of the above results is supplied by the value determined by Dr. Schlesinger from the photographic determinations made by right ascension and declination measurements. From 19 plates taken with the 40-inch Yerkes telescope during the years 1903-1906, three images on each plate, the value of the parallax was from RA = +0″.257; from Decl. = +0″.238; the mean of these, π = 0″.248, is essentially identical with Barnard's values. Krueger 60 is thus about three times as distant as α Centauri.—(*Monthly Notices*, R.A.S., No. 9, 1908.)

Orbital Elements of Algol.—R. H. Curtiss has investigated the second order variations of the variable Algol (β Persei), which have for many years past been indicated by minute and irregular fluctuations of the intervals between successive light-minima. Little was recognised of the nature of these changes before 1888, when Chandler showed they were closely represented by an empirical periodic expression involving three sine terms, with periods of 130, 35, and 16 years. Subsequent discussions have resulted in various explanations, chiefly bearing on the possibility of extra bodies capable of introducing perturbations in the system. Examining the hypothesis of a possible third body revolving close to the eclipsing pair, the author discusses the results of recent radial velocity determinations of the star. These are tabulated and show results from 1889 to 1907, which, when plotted, appear to indicate the presence of a periodic variation in the centre-of-mass velocity of Algol's eclipsing system, the character being such as to suggest a revolution of the system in a period of 1.9 years about a centre 89,000,000 km. distant. It is also probable that the orbit of the centre of mass is almost circular, and that at least three masses are involved in the system, two of which are extremely close, while the third is at a distance comparable with the earth's distance from the sun. As a consequence of the orbital motion of the centre-of-mass, a variation of about ten minutes in the time of light minimum, with a period of 1.9 years, should be shown by careful photometric observations.—(*Astrophysical Journal*, Vol. 28, p. 150, September, 1908.)

BOTANY.

By G. MASSEE.

Notes on an Australian Pitcher-Plant.—A very interesting account of the beautiful and interesting Australian pitcher-plant (*Cephalotus folliculatus, L.*), is given by Mr. A. G. Hamilton in the *Proceedings* of the Linnean Society of New South Wales. The plant is only known from one locality near Albany, West Australia. The statement in Kerner and Oliver's "Natural History of Plants," that it occurs in Eastern Australia is a mistake. The plants grow in a very wet situation and form perfect rosettes, the pitchers on the outside, and the ordinary leaves, when present, in the centre. The pitchers resemble the front part of a loose slipper, the lid is almost circular and curves over the mouth. The pitchers vary much in size, also in colour, irregular reddish markings on a green ground being most general. Mature pitchers contain liquid up to the lower edge of the glandular surface of the interior wall. The quantity varies with the size of the pitcher. At first the liquid is white, but becomes greenish-black from the large quantity of animal remains found in it. Among the *débris* are usually wings of insects and moths, chitinous plates, etc., and large numbers of unicellular algæ, consisting of a green cell with a gelatinous envelope, probably a *Protococcus*, which certainly lives and multiples in the liquid. The living larvæ of a fly are also often present. Flies belonging to the Tabanidæ may often be seen hovering over the pitchers, and it is possible that the larvæ found in the pitchers may belong to this insect. In any case, the living larvæ are an example of one organism taking advantage of special conditions created by another, for its own benefit. It is known that an American flesh-fly lays its eggs on the rim of *sarracenia* pitchers, and the larvæ go down into the decomposing liquid mass, live there for some time, and then enter the ground to pass the chrysalis stage. Associated with this plant is a bird, which tears open the pitchers in search of larvæ. In Borneo, a spider forms a web near the rim of the pitcher, where it lies in wait for prey. If alarmed it dives down into the liquid. When the author was investigating the pitcher-plants, a frog, alarmed by his movements, dived into a pitcher, where it was enabled to hide its head and shoulders.

The liquid contains azerin or some similar compound, as insects falling into it are immediately wetted through and drowned.

Fossil Plants from Tertiary Times.—Mr. T. D. A. Cookerell has described and figured in *Amer. Journ. Sci.* certain fossil plants discovered in the North American Miocene. These remains represent a flora containing many genera at that time widely distributed over the Holarctic region, but which were in later times driven southward, and to-day exist in much more limited areas, some in Asia, others in various parts of America. They are stated to show very clearly that many of the ostensibly endemic genera of various regions may well have originated elsewhere, and

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are merely making their last stand where we now find them.

Amongst interesting plants enumerated are *Geaster florissantensis*, showing the rays of the outer peridium spread open exactly as in recent species. It occurs on a slab along with the remains of *Typha* and *Vemus*. Among gymnosperms, *Pinus sturgisi* is described as new, and said to agree closely in every respect with *P. taeda, L.* of the Eastern and Southern States. In angiosperms, several new species occur; *Ailanthus americana; Quercus knowltoniana*, represented by a much compressed acorn; *Rosa ruskiniana*, established from a flower bud; this species is dedicated to John Ruskin, whose copy of Lindley's "Rosarum Monographia," with many marginal notes, is in the author's library; *Anona spoliata*, which is said to be very near to the European *A. elliptica*, Vuger, from the Miocene of Radoboj; the latter, however, differs in having a cuneate base; *Robinia brittoni*, represented by a leaf, said to be scarcely at all different from the living *R. pseudacacia; L. menyarithes coloradensis*, represented by a crown bearing five leaves, in form and appearance exceedingly like the living *M. trifoliata, L.*

Hygroscopic Leaves.—Dr. Haunig announces in *Ber. d. deutsch. Bot. Gess.*, the first recorded instance of the alteration in position of living leaves, due to the varying amount of water present in the cell walls. He noticed that the leaves of various species of *Rhododendron* change their position and roll and unroll, under the influence of freezing and thawing respectively. This is considered as due to the relative amount of water present in the cell walls, and can be repeated in dead leaves, or in living leaves under the influence of narcotics, by proper methods for varying the amount of water in the walls of the cells.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon), F.I.C.

Silundum: A New Product of the Electric Furnace.—Until recently silicon carbide was only known in the amorphous or crystalline state, and it was commonly accepted that it was produced by the sublimation of carbon and silicon at high temperatures. It has been found, however, by Herr Bolling, that silicon vapours at a high temperature are absorbed by carbon, which itself remains unaltered, provided air be excluded. The new product, to which the name of *silundum* has been given, is obtained by placing the pieces of carbon in a mixture of carbon and sand and heating them in an electric furnace to a temperature of 1800° to 1900° C. The amount of combination between the carbon and the silicon depends upon the time, the temperature, and the size of the pieces of carbon. These may be either completely converted into the silicide or may be coated with a layer of silundum of any desired thickness. The form of the pieces of carbon makes no difference, and tubes of silundum may readily be obtained by converting the surface of carbon rods into the silicon compound and subsequently burning out the central core of unaltered carbon in a muffle furnace. Silundum has the general properties of other forms of silicon carbide. It is excessively hard, resists high temperatures, and is not attacked by acids in the cold. It is a conductor of electricity, but offers much greater resistance to the passage of the current than hard carbon. Hence it is a valuable material for apparatus for electrical heating. It can be used at as high temperatures as platinum, over which it has the advantages of cheapness and of being readily replaced. Silundum can be coated with nickel or enamelled. On the other hand, it is destroyed by metals in the fused state, and especially by iron, and this reduces its value in metallurgical work. Attempts have been made to use filaments of silundum in place of carbon in electric incandescent lamps, but after burning for a short time the glass becomes coated with a brown deposit, probably of silicon, and the new material is therefore obviously unsuitable for this purpose.

Bacterial Contamination of Milk.—An ingenious method of determining the degree of contamination of milk has been devised by Dr. Vaudin. It is based upon the fact that the anäerobic bacteria that effect the decomposition of milk form products which have a chemical reducing action upon a dilute solution of indigo carmine, gradually decolorising it. The test is made by placing about 5 drops of a 0.1 per cent. solution of indigo carmine in a 2-ounce flask, which is then filled with milk and closed with a glass stopper. The mixture has a light blue colour when viewed in transmitted light, but gradually becomes colourless on standing for a few hours. If the hands of the milker and the udder of the cow are washed before milking, and the milk placed in absolutely clean vessels, the mixture in the test may retain a blue tint for as long as 48 hours at the ordinary temperature (60° F.); but in the case of milk collected and kept under the ordinary conditions the colour will not last more than an hour or two. In Dr. Vaudin's opinion, milk fit for use should retain a blue tint for 12 hours at 60° F.; for 8 hours at temperatures between 60° and 68° F.; and for 4 hours at temperatures above 68° F.

A Curious Alteration of Tin.—A phenomenon presenting several points of resemblance to bacterial infection, but apparently of an inorganic nature, has been described by Dr. von Hasslinger. A piece of tin plate that had been kept for about two years at a temperature of 16° to 45° C., was found to have completely changed its appearance, the surface having become granular and dull. When particles from the surface of this grey tin were brought into contact with other pieces of tin a sort of inoculation occurred, and the bright surfaces soon became covered with dull patches, which developed at the rate of several millimetres a day. The growth of this so-called "tin pest" was not affected by a rise in temperature, and in this respect it differed from bacterial growth on organic substances; but the development of the patches was less vigorous at a distance from the point of inoculation. Tin that had undergone this alteration melted at a lower temperature (205° C.) than the original tin, which melted at 231°-232° C. On melting the grey tin it regained its normal characteristics and again melted at the original temperature. No explanation has yet been suggested for this curious alteration, which appears, however, to be due to the formation of an allotropic modification of tin.

GEOLOGY.

By EDWARD A. MARTIN, F.G.S.

The San Francisco Earthquake.—In a paper read before the Geological Society of London, Mr. R. D. Oldham has endeavoured to interpret the earth-movements connected with the Californian earthquake of April 18, 1906. He stated that at the time of the San Francisco earthquake, movement took place along a fault, known as the San Andreas fault, which can be traced for a distance of about 200 miles. A remeasurement of the primary triangulation in the region shaken by the earthquake revealed considerable displacements, increasing in amount as the fault is neared, and of such nature that places to the east of the fault were shifted southwards while those to the west of it were shifted northwards. Mr. Oldham pointed out that the extent and peculiar distribution of these displacements negative the supposition that the fault was the cause, but it must rather be regarded as a consequence of, or an incident in, the earthquake, this word being used to denote the disturbance in its entirety.

The surface-displacements constituting an earthquake, as ordinarily understood, arise from disturbances in the outer skin of the crust of the earth, but in great earthquakes, like the one dealt with in the paper, these may be the result of more deep-seated disturbances affecting the whole crust of the earth. A distinction is drawn between these two forms of disturbance, and the term bathyseism is proposed for the deep-seated disturbance; the wave-motion which impresses itself on distant seismographs and constitutes the teleseism or world-shaking earthquake being the product of the bathyseism.

The deep-seated cause, or bathyseism, of the San Francisco earthquake is regarded as the result of a wide-

spread strain, of the nature of a shear, such as might have been produced by displacements approximately parallel to the general direction of the coast-line, and by forces which must have been very different from those concerned in the formation of the San Andreas fault. This fault cannot, consequently, be regarded as the cause of the earthquake, nor the earthquake as an accident in the growth of the fault.

Deep-Seated Causes and Effects.—It appears that the great earthquake quoted must have had its origin in some deep-seated cause, and probably the San Andreas fault was but the result of a much earlier quake in times that are pre-historic. The movement of the sides of the fault in different directions was but the consequence of something—no one knows what—happening far down beyond the range of geological observation, and this shock was that which proved so destructive. This shock caused the destruction of San Francisco, and it caused the sides of the fault to shift. Both were due to some unknown cause. At the same time, the very movement along the fault would, it may be supposed, produce shakes on a small scale in its vicinity, and such might in our country, in the absence of greater shocks, be dignified by the name of earthquakes. It would be interesting to know if any secondary shocks were felt at distant places after the lapse of an appreciable time, such as would result from the passing of the wave of energy through instead of along the surface of the crust, or even through a central core, if there be one, or by reflection from that solid core, such as have been conjectured in the cases of other great earthquakes.

Geologists' Association Jubilee.—The Geologists' Association, which may be regarded as the sociable companion of the Geological Society, commemorated its jubilee on November 27, by a conversazione at University College, Gower Street, W.C. The guests were received in the Flaxman Gallery by the President, Professor W. W. Watts, and lecturettes were delivered by Professor E. J. Garwood and Mr. J. W. Young. A large collection of geological exhibits of all kinds were on view, lent by about fifty geologists. A jubilee volume, showing the past record of the Association, with particulars of geological sections visited, is to be issued by the Council.

Eolithic Implements.—After nearly twenty years of heated discussion on the great Eolithic question, there seems to be little doubt that, in spite of a few who are still unconverted, eolithic implements have taken their place permanently in the archæologists' repertory. Benjamin Harrison has lived to see his work appreciated, and an army of devoted adherents willing to fight his battles for all time. Eolithic is a stage rather than a time. Eoliths are sometimes found with palæoliths, for even amongst palæolithic men there were eolithic children, but where, as in Prestwich's Southern Drift, there are eoliths and eoliths only, then humanity was, in those places where the Southern Drift is found, in the child-like eolithic stage, although possibly elsewhere the race had reached the palæolithic stage. Mr. N. F. Robarts has recently been calling the attention of Croydon geologists to the subject so far as the Southern Drift running up the Croydon Valley from Merstham is concerned. He quotes the discoveries made in regard to the native Tasmanian race which died out about 60 years ago. He says that this backward race, apparently the most backward race in the world, was actually making eolithic implements before they disappeared. A commission has been investigating their latest settlements, and has collected implements which but for material would be indistinguishable from the eolithic implements of the Kent and Surrey plateau, or those of Belgium. Mr. Robarts adds, if only the race had existed for another 60 years, the eolithic controversy would possibly never have arisen.

The Glasgow Geological Society.—The Geological Society of Glasgow, instituted in 1858, has now entered the 51st year of its existence. The Council have made arrangements to celebrate the event by holding a jubilee meeting in Glasgow University on the 28th January, 1909. Sir Archibald Geikie, P.R.S., the senior member of the Society, has promised to be present and deliver an address. Sir Donald MacAlister, Dr. J. J. H. Teall, Director-General of the Geological Survey of Great Britain, Dr. Horne, Dr. Peach, and other eminent men of science will take part in the proceedings. A history of the work of the Society, with biographical notices of prominent members, is being prepared under the editorship of the secretaries, Messrs. Peter Macnair, F.G.S., and Frederick Mort, B.Sc., F.G.S., who hope to issue the book by the end of the year.

Folk-Memory.—Under the title of "Folk-Memory," the Clarendon Press has issued a book, by Walter Johnson, F.G.S., which may be regarded as a compendium of reference to the various kindred subjects which are classed under the modern study of Archæology. At the same time, the chapters show that they have not been written without study at first-hand in the field, and Mr. Johnson's conclusions are interesting and trenchant. By "folk-memory," he states that he means the conscious or unconscious remembrance, by a people collectively, of the ideas connected with the retention of rites and superstitions, habits, and occupations. Such memory may be clear and sound, the outcome of an unbroken succession of impressions, but these may be dim and fugitive, almost at times verging to the point of extinction.

He traces in many existing habits and occupations the memory of traditions handed down from, it may be, a period long lost. He discusses ably the continuity of the ages of stone and bronze, and deals with such things as the megaliths of our open downs, fairies, barrow superstitions, the ancient history of flint-knapping, dene-hills, linchets, and dew-ponds; as well as the giant figures carved on our chalk downs, pilgrim's ways, and other old roads.

In the chapter on dew-ponds, Mr. Johnson refers to our recent articles in "KNOWLEDGE," on the subject, and reviews in a useful manner the evidence for the antiquity of these ponds. Folk-memory on this subject is, to a great extent, wanting. He is inclined to think that these ponds do not ante-date the period of the mediæval sheep-masters; although he admits the likelihood that dew-ponds of some kind were known in the Neolithic and the Bronze ages, not only by the primitive settlers on hill-tops, but also by the temporary inhabitants of the hill-forts. In dealing with our oldest industry, namely, the fabrication of implements and appliances of flint, he shows the transition from the earliest times in the hunting-stage of man's existence, from the rude Eolithic implements of the Kentish plateau, and the Cromer forest bed, down through the Palæolithic and Mesolithic stages, and on to the beautifully chipped or polished implements of Neolithic man. More recent still, he refers to the "pigmy" implements as Aeneolithic, correlating them with the Robenhausian sub-division of continental geologists. The book is one which will be a necessity to every student of primitive man. It will no doubt give rise to considerable controversy, but this is inevitable from its very nature. It will, however, be extremely useful as a work of reference, and will point the way when one desires to look up ancient authorities.

Genesis of Metallic Ores.—"The Genesis of Metallic Ores and Rocks which Enclose Them" is the title of a book on economic geology, by Mr. Brenton Symons (The Mining Journal, London). In this work the author has endeavoured to avoid perplexing the general reader who is interested in such subjects, at the same time producing a book which will be of the greatest possible use to those who may be engaged in mining pursuits. One half of the book is of a purely geological nature, and can be read with profit by even advanced students. The latter half deals more particularly with the occurrence of metallic ores in veins and lodes, and gives striking instances of the strange methods of occurrence of minerals. A good many technical terms are introduced, but these are explained as progress is made. The book is well illustrated, there being 154 representations of rocks and sections of mines, and there is also a complete index. Attention is called to the table on the final page, showing the stratigraphical range of metals, arranged on the principle formerly adopted to show the introduction, increase, and final extinction of various classes of zoological and botanical life throughout

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the geological systems. From this table it appears that tin was chiefly deposited in Cambrian times, and it rapidly thinned out until Jurassic times. Iron pyrites is found chiefly in Laurentian rocks, but its prevalence rapidly thinned out, until, in Silurian rocks, it is found in about the same proportions as it is in tertiary rocks. Tellurium is found chiefly in Cambrian rocks, and to some extent in Silurian, but there is none in more recent rocks. The pictorial method of representation of the occurrence of metals is very striking.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

Agriculture and the Recent Mild Weather. — The Agricultural correspondent of the *Times* on December 14 said: Reports from different parts of the country continue to dilate upon the abnormal nature of the season. Correspondents of all ages declare that they cannot recall an autumn equal to that of the present season for mildness and productiveness. Farmers had abundant opportunity for sowing as extensive areas of wheat, beans, and catch crops as they desired, and as the work had been completed early last month the plants are now well above ground and present a healthy and thriving appearance. There is scarcely a discordant note in the comments upon the winter corn and beans; and if the mild weather continues much longer there will be a danger of wheat becoming what is termed winter proud, and in that event the turn of the year may witness a revival of the declining practice of running the flocks over the wheat plant. In regard both to field work and the condition of the winter cereals, the present season contrasts pleasantly with last year; and with the prices of grain maintaining a fairly high level, which is likely to be continued throughout the cereal year, arable farming presents a more reassuring complexion than it has for some time past.

The Climate of Orkney. — Mr. Magnus Spence has an interesting paper on this subject in the Journal of the Scottish Meteorological Society. He shows that the climate of Orkney is very much like that of the east coast of Scotland. Its extremes of temperature are not so great, but its rainfall is slightly higher. The growth of vegetation is often greatly retarded in spring, considerably more so than on the mainland of Scotland. During April, May, and June, till Midsummer Day, spells of cold weather with a northerly wind set in and prevent the progress natural to the season. Then gales, as those of 1890 and 1907, wither the growing grain and check vegetable growth for at least a fortnight. After that rapid progress takes place, and heavy crops are often produced. Harvests are generally a fortnight later than in Aberdeen, but seed-time is also much later. Bere, which is much grown on land where seaweed is available, has been often sown in the third week in May and cut in the second week in August, thus growing and ripening in eleven weeks. It has been known to do this in ten weeks, but that is unusual.

The Orkneys surpass any other district in Great Britain in the number of gales. How do all these winds affect the inhabitants? Strangers say the voice is louder, to make oneself heard above the warring elements, and that the rising intonation at the end of the sentence is a last effort to outdo the thunderous furies. This is more marked still in the small islands, where it is impossible to get away from the reverberating sound of ocean's roar. It is also said that the ever-recurring blast has made the footsteps heavier and the countenance more stolid and sombre. A gale every third day would have some such effect.

Investigation of the Upper Atmosphere. — At the meeting of the Royal Meteorological Society on December 16, Mr. C. J. P. Cave read a paper on "The Registering of Balloon Ascents in the British Isles, July 27-August 1, 1908." These ascents were made in connection with the extended series of ascents of kites and balloons arranged by the International Commission for Scientific Aeronautics. Twelve balloons were sent up for the Meteorological Office under the direction of Mr. W. H. Dines, F.R.S., six ascents being from Crinan, on the west coast of Scotland, and six from Pyrton Hill, Oxfordshire; six were sent up by the Meteorological Department of the Manchester University under the direction of Mr. J. E. Petavel, F.R.S.; six by Captain C. H. Ley, from Birdhill, Co. Limerick, for the Kite Committee; and four by Mr. Cave from Ditcham Park, Petersfield, Hants. Of those sent up, four from Crinan, five from Manchester, three from Pyrton Hill, and two each from Birdhill and Ditcham have been recovered. The meteorographs used were of the type designed by Mr. Dines, in which the traces are made on copper plates electroplated with silver. Some of the records show considerable differences of temperature between the up and the down traces, which seems to indicate that fairly rapid fluctuations of temperature may occur in the upper air. The average height reached was 10.2 miles; the greatest height being 14.3 miles. All the balloons except one reached the "isothermal layer," and show that the diminution of temperature with height ceases after a certain point, or that there is a rise of temperature; the rise of temperature is quite marked, even in the case of balloons which have attained their highest point after sunset, and cannot therefore be the effect of solar radiation.

Mr. C. J. P. Cave also read a paper on "Balloon Observations at Ditcham Park, near Petersfield, July 27-August 2, 1908." He described how the registering balloons which were sent up were followed by means of theodolites for the determination of wind velocities at different heights. The balloons were observed until after they had entered the "isothermal layer," and in each case there was a well-marked diminution of wind velocity at its lower limit.

ORNITHOLOGY.

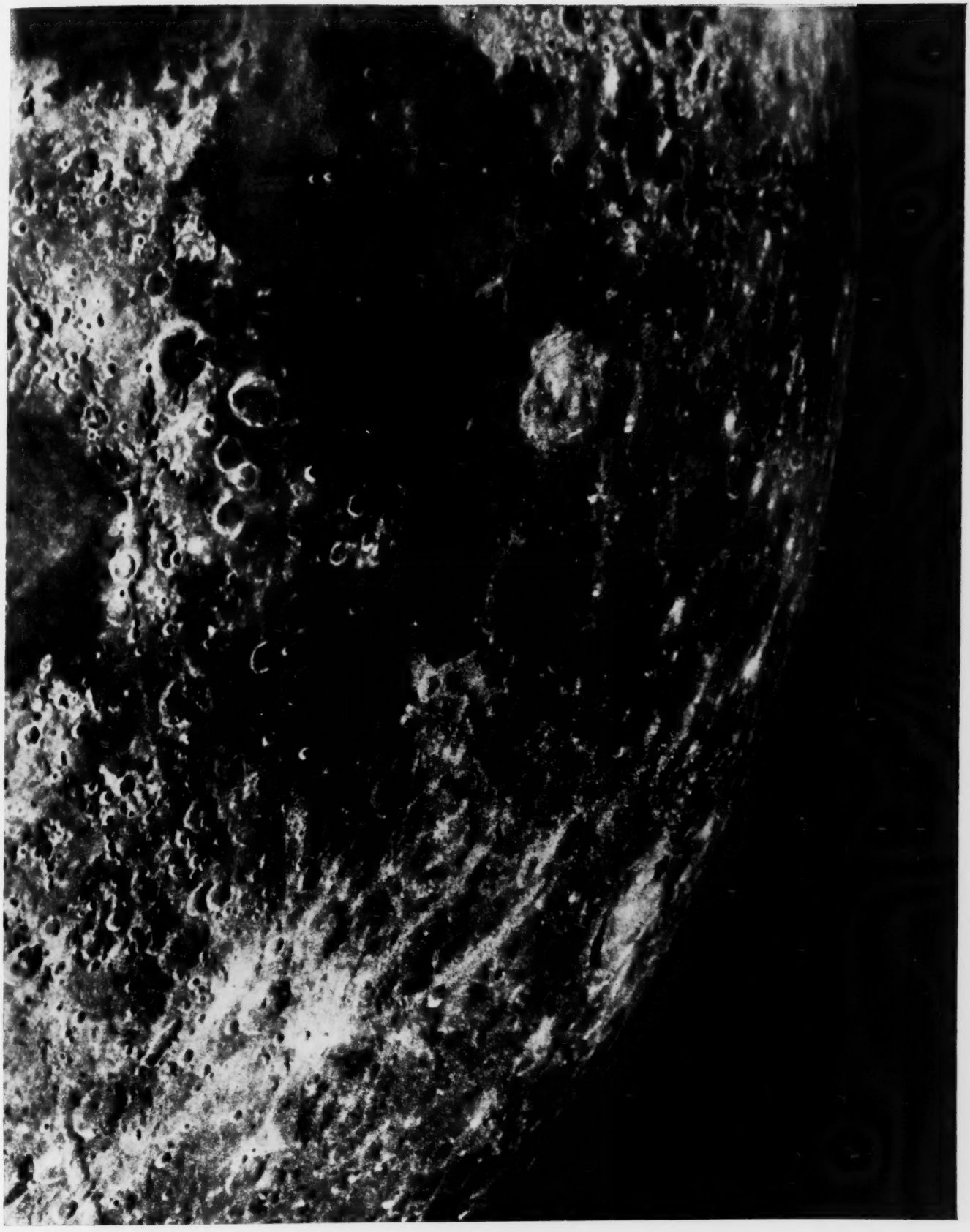
By W. P. PYCRAFT, F.L.S., F.Z.S., M.B.O.U., &c.

The British Ornithologists' Union. — The British Ornithologists' Union celebrated its 50th anniversary in the rooms of the Zoological Society of London, on Wednesday, December 9. The occasion was marked by an address from the President, Dr. F. D. Godman, F.R.S., and the presentation of a gold medal to each of the four survivors of the original founders—Dr. F. D. Godman, Mr. Percy Godman, Dr. P. L. Sclater, F.R.S., and Mr. W. H. Hudleston, F.R.S.; Mr. Henry Upcher, the oldest of the original members, making the presentation.

The proceedings terminated with a dinner in the evening, after which Mr. Boyd Alexander gave a thrilling account of his wonderful journey across Africa, and Mr. Kearton showed some wonderful cinematograph pictures of bird-life.

The Union and Bird Protection. — It is a matter for regret that the British Ornithologists' Union should have to frame a drastic measure designed to secure the expulsion of members who choose to set at defiance all codes of decency in the matter of collecting rare British breeding-birds and their eggs. But such is the case, and this rule was passed on the day following the anniversary meeting. As it now stands, any member who "shall have acted in a manner injurious to the interests or good name of the Union, or shall have personally assisted in, or connived at, the capture or destruction of any bird, nest, or eggs, in the British Islands by purchase or otherwise, likely to lead to the extermination or serious diminution of that species as a British Bird, the Secretary shall be directed to send a registered letter to the member stating the facts brought before the Committee, and asking for an explanation of the same. . . . after allowing a reasonable time for reply . . . . the Committee, provided not less than four are agreed, shall have power to remove that gentleman's name from the list. . . ." We hope this rule will never have to be enforced; but circumstances have, unfortunately, rendered its formation a necessity.

Dipper in Kent. — Mr. A. H. Hardy, in the *Field* (December 19), records the fact that he saw a Dipper down by the Stour, on December 11. He got quite close to the bird, and so had a good view of it.



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The Moon.

The above represents a portion of the first quarter.

Aquatic Warbler in Sussex.—In the December number of *British Birds*, Mr. E. C. Arnold contributes a note on an Aquatic Warbler (*Acrocephalus aquaticus*), which he shot on the Eastbourne Crumbles on October 7, 1908. And this he supplements by an admirable drawing of the bird.

Little Bunting in Ireland and Norfolk.—At the meeting of the British Ornithologists' Club held on October 21, Mr. W. R. Ogilvie Grant, on behalf of Mr. R. M. Barrington, exhibited a female specimen of the Little Bunting (*Emberiza pusilla*), which was picked up at the Rockabill Lighthouse, off the coast of Co. Dublin.

At the meeting of the Club held on November 18, Mr. A. F. Witherby exhibited another specimen of this species—also a female—which had been killed at Cley-next-the-Sea, by a local gunner on October 9.

Bulwer's Petrel at Hastings.—At the meeting just referred to above, Mr. Ogilvie Grant, on behalf of Mr. C. J. Carroll, exhibited a male example of Bulwer's Petrel (*Bulweria bulweri*), which had been picked up after strong south-westerly gales at Cliff-end, Pett Level, near Hastings, on September 4, 1908. This makes the fourth occasion of the occurrence of this Petrel in the British Islands.

Buff-Breasted Sandpiper in Lincolnshire.—In *British Birds* (December) Mr. G. H. Caton Haigh records the fact that he shot a specimen of the Buff-Breasted Sandpiper (*Tringites rufescens*) at North Cotes on September 20, 1906.

Sabine's Gull in Lincolnshire.—Mr. Caton Haigh, in the same issue of this magazine (*British Birds*), has a note to the effect that he shot, on September 28, 1908, an example of Sabine's Gull (*Xema sabinii*), off Grainthorpe Haven, but in immature plumage.

Pratincole in the Flannan Islands.—In the last number of the *Annals of Scottish Natural History*, Mr. W. Eagle Clarke records the fact that an adult female Pratincole (*Glareola pratincola*) was shot on July 13, 1908, making the third record for Scotland.

PHYSICS.

By PROFESSOR A. W. PORTER, B.Sc.

Gaseous Ionization and Pressure.—When Gamma rays act on a constant volume of a gas it is to be expected that they will produce an amount of secondary radiation proportional to the pressure of the gas; further, the ionization arising from this secondary radiation is also proportional to the gas pressure; thus the ionization would be proportional to the square of the pressure. Messrs. T. H. Laby and G. W. C. Kaye have recently made experiments on this question over a range from 1 to 17 atmospheres for hydrogen, air, and carbondioxide when contained in an aluminium vessel and exposed to hard γ-rays from radium; and from a discussion of their results they conclude that the ionization arising

(*a*) From the Gamma rays, which is small in amount, varies as the pressure.

(*b*) From the secondary β-rays (excited by the γ-rays) from the aluminium electrodes varies as the pressure, while that excited in the gas itself produces ionization small in amount and proportional to the square of the pressure.

(*c*) From a soft tertiary radiation increases less rapidly than the pressure.

It is further inferred that when β-rays (velocity about half that of light) are absorbed they excite soft secondary β-radiation.—(*Phil. Mag., December, 1908.*)

The Spectrum Lines of Sodium Vapour.—Up to the present time only seven spectral lines belonging to the principal series of sodium have been discovered. But now Professor R. W. Wood has succeeded in extending this number to thirty, and thus reached a number greater than that for any other known series, for the greatest hitherto was twenty-nine for hydrogen, the last line of which is only 15 A.U. from the theoretical end of the series. In the case of the new sodium lines—which are observed as absorption lines in the ultra-violet—the last six are so close together that with the apparatus employed it was impossible to determine their wave-length. To find these it was not necessary to select them from a number of lines belonging to several series, for in the absorption spectrum the principal series appears alone.

The vapour was obtained by heating the metal in a steel tube about a metre long to a dull red heat. It is almost opaque to all visible radiations, only the extreme violet being transmitted. The source of light was a cadmium spark furnished by a large induction coil with condenser; this gave a fairly bright, continuous background, and has no bright lines which coincide with any of the sodium lines. The spectrum was photographed with a small quartz spectrograph. So far the lines of higher frequency in this series do not appear in the emission spectrum, but attempts are being made to obtain them.

Diffusion of Nascent Hydrogen Through Iron.—Winkelmann takes an iron tube closed below and dips it in acidulated water, which serves as a cathode. Above it communicates with a glass tube bent so as to form a mercury manometer. A vacuum is made inside the apparatus and a current passed. The liberated hydrogen slowly diffuses through the iron. The velocity of the diffusion is independent of the pressure of the hydrogen already accumulated in the tube. Nor does it vary when the external pressure is reduced from one to half an atmosphere. It increases rapidly when the temperature, and also when the current, is increased, but its increase with current is less rapid than the increase of the current itself.

Electric Splashes on Photographic Plates.—When a spark is passed between two terminals on to an interposed sensitive plate and the plate developed in the usual way the path of the electric discharge consists partly of a main line, which passes over the plate from terminal to terminal and in part traces out a pattern which depends upon which pole is on the sensitive side. When the pole is negative, the pattern consists of palm leaf figures terminating and branching from lines of discharge. When the pole is positive the ramifications are much more moss-like. If a magnetic field is superposed by inserting the plate between the poles of an electromagnet the effect of the field upon the splashes can be investigated. It is found that there is no perceptible action except upon the *main line of discharge*. This main line, in the absence of the magnetic field, consists of a broad, irregular band with a much more intense line passing about midway along it. When the magnetic field is excited the intense line is not perceptibly (if at all) disturbed, but the broad band is shifted entirely to one side of it. If several of these main discharges are present, radiating out from the central electrode, the shift takes place in the same sense with them all, being clockwise or counter-clockwise, according to the direction of the field. The effect is very much the same as if a cyclone had blown aside the glowing gas in the main discharge. Indeed, an effect which cannot be distinguished from the effect of the magnetic field is obtained by directing a blast of air across the plate when passing the spark. The fact that the rest of the splash is not perceptibly affected by the field seems to indicate either that the bodies carrying the electric charge are very massive or that they move very fast, or else that the splash is mainly produced by causes which are altogether independent of the motion.

ZOOLOGY.

By R. LYDEKKER.

The Immortality of Animals.—Judging from letters received, the paragraph under this heading in the November issue seems to have excited considerable interest among the readers of this journal. Two writers profess to have solved the difficulty alluded to in the paragraph in question; but, so far as I can see, merely confuse the issue by introducing a number of speculations concerning the relations of mind, soul, and body. Personally, I have no definite opinion upon the question one way or another, and must therefore decline to be drawn into a controversy.

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The Distinctness of Marsupials.—In my last notes I alluded to evidence derived from development and the relations of the ureters as to the distinctness of marsupials from other mammals. Further evidence in the same direction has recently been brought forward by the Prosector to the Zoological Society, in the October issue of the Society's *Proceedings*, derived from a study of the digestive tract. It is there shown that in the carnivorous Australian representatives of that group, especially in *Antechinomys*, the intestine is of a very simple and reptile-like type, being attached in the genus mentioned to a continuous mesentery. A similar type of intestine occurs in the great ant-eater, which is likewise a very lowly creature; and it is further shown that in certain carnivora and insectivora the digestive tract is also of a more or less simple type, although in the second of these groups the simplicity may be due to reversion. All this points to the conclusion that several groups of mammals have inherited a simple type of intestine from reptilian ancestors; and it is specially significant that the simplicity is so strongly marked in marsupials. The occurrence of a medium type in carnivora is also noteworthy, since I am convinced that this group was derived directly from reptiles by means of the extinct creodonts. Another significant point is the retention of a simple and primitive type of intestine by cetaceans (whales and dolphins), since palæontology has rendered it practically certain that this group takes its origin from the aforesaid creodont carnivora.

The Labyrinth of the Ear.—In the review columns of this journal reference will shortly be made to Dr. Albert Gray's volumes on the structure of the labyrinth of the internal ear. In that work attention is mainly directed to the structure of this organ in the various groups of mammals. The author, in a paper just published in the *Proceedings* of the Royal Society, has now extended his investigations so as to explain the homologies existing between the constituents of this organ in mammals, birds, and reptiles; and his conclusions are of the very highest importance alike from the morphological and the taxonomic standpoint, although somewhat difficult to explain in popular language without the aid of diagrams. In the higher mammalian cochlea is a membrane-covered aperture known as the *fenestra rotunda*, or "round-window." According to the new discovery, this corresponds with two structures in birds and reptiles; representing from the point of view of evolution an opening low down in the perilymph recess of the latter, which is closed by membrane, but as regards position corresponding with the oval aperture existing in birds and some reptiles between the cochlea and the perilymph recess. Further, the structure known as the ductus perilymphaticus in reptiles does not exist in mammals and birds; while the true ductus perilymphaticus of the latter is represented merely by an oval dehiscence in the roof of the perilymph recess (wanting in higher mammals) of the former. Apart from technical details, the main interest and importance of Dr. Gray's work lies in the fact that it affords evidence of a gradual evolution in the structure of this part of the labyrinth from the reptilian to the higher mammalian type. Thus, in the egg-laying mammals there is a distinct perilymph recess, carrying the round window on its upper surface, quite distinct from the cochlea. In marsupials the base of this chamber becomes merged in the side of the cochlea; in ungulata and carnivora the fusion becomes more pronounced; while in primates the perilymph chamber has completely disappeared, the round window opening in the side of the cochlea, and below it being the perilymph duct, which in the lower forms discharged from the outer end of the perilymph chamber far away from the wall of the cochlea. All this is further evidence of the distinctness from other mammalia of marsupials and egg-laying mammals, and also of the near affinity of the latter to reptiles.

Papers Read.—At the meeting of the Zoological Society held on November 17, Dr. N. Annandale communicated an account of a new genus and species of slow-lemur from the Lushai Hills, Assam, based on a photograph of two specimens taken in 1889. The creature is stated to resemble *Nycticebus*, but differs by its long, bushy tail. Gastropod molluscs of the family *Neritidæ* formed the subject of a paper by Mr. G. C. Bourne. A general account of the zoological results of an expedition to the Ruwenzori range of mountains of Equatorial Africa was given by Mr. W. R. Ogilvie-Grant; and at the same time a number of papers describing the various groups collected were submitted to the meeting.

The papers down for reading at the meeting of December 15 comprised the following: A hunting trip to the Thian-Shan, by Mr. F. Gillett; the anatomy of the batrachian genus *Hemisus*, by Mr. F. E. Beddard; a new lizard from Persia, by Mr. G. A. Boulenger; remarks on wart-hog skulls, by Dr. Einar Lönnberg; Chinese serow-skulls, by the present writer; warning-colours in the *Mustelidæ*, by Mr. R. I. Pocock; a new river-crab from New Guinea, by Dr. W. T. Calman; and mammals from Shan-si and Shen-si, North China, by Mr. O. Thomas.

REVIEWS OF BOOKS.

ASTRONOMY.

Annals of the Astronomical Observatory of Harvard College, Vol. 50 (Revised Harvard Photometry, a catalogue of the positions, photometric magnitudes, and spectra of 9,110 stars, mainly of the magnitude 6.50 and brighter observed with the 2-inch and 4-inch meridian photometers. Vol. 61, Part I. Researches of the Boyden Department, by William H. Pickering).—The flow of publication provided for by the various funds under the control of Professor E. C. Pickering shows no sign of slackening, though the enforced irregularity of the progress of the annals is emphasised by the appearance at the same time of two such volumes as 50 and 61. This is, of course, a tribute to the many-sided activity of Harvard College Observatory. The revised photometry will be of enormous value, especially for the numerous variable star observers with small equipment. It contains the results of measures made during the years 1879 to 1906, involving more than a million settings on stars from the north to the south pole. It gives, as may be expected, data for identification from certain standard catalogues, including the original Harvard Photometry, the places for 1900, the photometric residuals and also catalogue residuals from a comparison with other well-known photometries, and, of course, the magnitude and spectrum classification. Among the tables at the end will be found a useful index to Bayer and Lacaille letters, enabling anyone whose knowledge of stars is confined to the more conspicuous ones by name and not by place to identify them readily in the catalogue. The second portion of the annals, now under consideration, is of very great general interest, the large Boyden bequest being specifically directed towards investigations in a situation as nearly as possible free from atmospheric disturbance, a great deal of time and energy was necessarily devoted to the determination of a scale of "seeing," and to the discovery of a site where good conditions were the rule. Considerations of altitude, latitude, wind, and humidity successively engaged the attention of the searchers, and much difficulty was found in adopting a simple test. Professor Pickering gives as, perhaps, the simplest and most readily and generally applicable criterion, the visibility of the ellipticity of Jupiter's first satellite, which, he says, should be fairly obvious with good seeing in any telescope with an aperture of not less than five (possibly four) inches. The expeditions to Pike's Peak, to Southern California, to Peru, and to Jamaica afford excellent examples of the kind of difficulty encountered. The number of different investigations undertaken is also very interesting, including varying curvature of mirror, diameter of stellar discs and rings, effect of diminishing aperture, lunar photometry, diameters of satellites of Jupiter and Saturn, with a chapter on the orbit of the tenth satellite of the latter, and a discussion of the variability of Linné, with deductions as to the presence of air and water on the moon. Now that the preliminaries may be regarded as quite disposed of it is to be hoped that a long career of practical usefulness awaits the Boyden researches.

The Moon; A Popular Treatise, by Garrett P. Serviss (London: S. Appleton, 1908; pp. xii. and 248, and plates; 6s. net).—Yet another book on the moon. This time a conversational treatise after the manner of Fontenelle, but having for its subject instead of "The Plurality of Worlds," a fine series of lunar photographs, taken at different phases

by Mr. Wallace, of the Yerkes Observatory. Round these photographs, to which are added half-a dozen large-scale photographs of special regions, such as Copernicus, by Professor Ritchey, is written in dialogue form a sketch of the state of modern knowledge of the lunar surface, its history and supposed constitution, with especial reference to the form and nomenclature of the more prominent features. It need hardly be said that the photographs themselves are admirable. Moreover, they have been well-reproduced, and Mr. Serviss, who is well-known as a popular writer on the subject of astronomy, has succeeded in producing a readable book out of what might at first sight appear very unpromising material. It is true that the reiteration of "my friend" is apt to become wearisome, and we would suggest that a fancy name, "Stella," for instance, would be an improvement without destroying the anonymity of a presumably imaginary lady. The author does his best to render his dialogue "life-like," by allowing his interlocutor to ask occasional questions, which he cannot answer, but one feels that in a real conversation more time would be wasted on digressions, the absence of which, though necessary, renders the style less convincing. We doubt if the method once adopted could have yielded a better result in any other hands. As is only natural, Mr. Serviss makes frequent references to the ideas of Elger, whose work on the moon is well-known, and has taken great pains to ensure accuracy in his book. When in doubt as to the meaning of a Latin word, however, we would suggest that it savours too much of "realism" to apologetically use a wrong translation, though that would be the obvious course in a real conversation. In this, however, we may be doing the author an injustice.

BOTANY.

Mosses and Liverworts: An Introduction to their Study, with Hints as to their Collection and Preservation, by T. H. Russell, F.L.S. (London: Sampson Low, 1908; 4s. 6d. net).—The present book is a welcome addition to our existing literature on mosses and liverworts, and forms a connecting link between the two extreme types of book at present extant. One such type is the systematic work, whose one object is to enable anyone to ascertain the name or series of names given to a particular plant by our predecessors. The amount of morphology necessary for this purpose being mostly confined to determining the structure of the margin of the leaf, form and arrangement of cells, position of the sexual organs, etc. The second type of book deals in detail with the minute morphology, cytology, the processes of fertilisation, etc., and by systematists generally is considered as treating of subjects lying outside their sphere of work. The author of the book under consideration has taken a medium course, and has clearly indicated how much general and specific information may be obtained relating to the life-history and structure of mosses and liverworts in general, without necessarily burdening the memory with the name of every British species. Commencing with the spore, and following on through the different stages of development, until the formation of spores is again reached, the reader is introduced to the various structures in succession, their modifications from type to meet exceptional conditions being indicated. A final chapter is devoted to the collection and preservation of specimens for the herbarium and for future microscopic investigation.

Ten plates, containing numerous excellent figures, drawn by the author, add much to the value of the book.

The Origin of a Land Flora. A Theory based upon the Facts of Alternation, by Professor F. O. Bower, F.R.S. (London: Macmillan and Co., 1908; pp. xii. and 727; with numerous illustrations; 17s. net).—Professor F. O. Bower's enunciation of his hypothesis of the steps by which the plants of the land emerged from the primeval sea, evokes a consideration once more of the value and purpose of a theory. A theory is valuable according to the number and variety of facts for which it affords an adequate explanation and which it effectively relates to one another. It becomes invalid if any conspicuously large number of facts refuse to range themselves under its generalisations; but it becomes merely less valid if a small number are recalcitrant, and it may lose little of its value as a means of arranging facts while some of its generalisations are in dispute. Professor Bower's working hypothesis may be broadly stated as follows:—That the land flora emerged from the sea as an egg-cell enclosed in a prothallus; that the egg-cell broke up into zoospores; and that from these zoospores the vegetation of the land developed. The theory is based on the known facts of the "alternation of generations" in plants. In the life-history of a fern we see a type of the regular alternation of sexual and asexual generations, which characterises the higher plants. In the ferns the asexual generation is the plant itself, while the sexual phase is represented by the small and simple prothallus. In the mosses and liverworts, on the other hand, the arrangement appears reversed; the main vegetative development is in the sexual stage, while the asexual generation is merely the fruit (sporogonium) dependent on the sexual plant which bears it. In both classes there is, in Professor Bower's phrase, "a marked difference between the two phases, and their sequence may be said to constitute an 'antithetic alternation.'" But by "antithetic alternation" Professor Bower usually implies his view that an "asexual generation" was at some point intercalated, thrown into, the life cycle of plants; and that it is therefore newer than the sexual phase or gametophyte. With this as starting point he develops the theory that the asexual sporophyte, however it may have arisen, conquered the dry land; the gametophyte, with its conservative adherence to traditional methods remained dependent on a more or less watery environment, until the seed plants came to be evolved. Then the prothallus became a mere parasite on the sporophyte, enclosed within the megasporangium, so that fertilisation could take place on the plant itself. But the point which is at issue is whether it is necessary to assume that there was a distinct and separate origin for the two generations in the life-cycle of plants. With the greatest respect, we cannot but think that the recent work of Lloyd Williams and Mothes forces us to take note of an exception fatal to the validity of Professor Bower's hypothesis. Lloyd Williams has shown that in the alga Dictyota there is a regular alternation between the sexual and asexual generations, though these generations are in all morphological aspects similar to one another. There can be no question of intercalation here, and the case of Dictyota (as well as more complex cases) shows the cytological distinction may exist between generations which are clearly homologous with one another. So far as the evidence from the thallophyte is concerned it seems that recent work favours the origin of the alternating generations by the modifications of homologous individuals rather than by the intercalation of an entirely new phase in the life cycle. But even if we assume that a number of important facts are not susceptible of explanation by Professor Bower's theory, we have nothing but admiration for Professor Bower's masterly presentation and arrangement of his detailed observations. His book is a great contribution to systematic botany, and one of the most important published in England during the last generation. Many of its conclusions as to morphological progress and groupings of the early plants are independent of his antithetic alternation theory; and nothing can confer higher distinction on English botany than the publication of this treatise from the hand of an acknowledged master of the facts of his subject.

The Flora of West Lancashire, by J. A. Wheldon, F.L.S., and Albert Wilson, F.L.S. (Published by the authors at 60, Hornby Road, Walton, Liverpool; 12s. 6d.).—In the preface the authors state that "The idea of including what is known as a Botanical Survey on lines recently much advocated was considered and abandoned." This was undoubtedly a wise decision; the flora of a given district as it exists at the present day is a matter quite apart from the ecology of the same district and the game of ecology as it is played in limited areas, and as the outcome of a very brief period of research, may be ignored. The points attempted, and very successfully carried out in the

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work under consideration, are a descriptive introductory chapter, dealing with the topography, meteorology, and climate, vertical and horizontal range of species, and distribution of mosses, hepatics, and lichens. Ecology, inasmuch as the influence of altitude, nature of rocks and soils, humidity, temperature, etc., bear on the distribution of plants is discussed. West Lancashire includes that portion of the county south of Westmorland, and north of the Ribble, and corresponds to Watson's V.C., 60. The arrangement of species adopted in "The London Catalogue" is followed, and the scientific names are those given in the "British Museum Catalogue of British Seed Plants." Under each species, its claim to "Citizenship," area of distribution, habitat, frequency, first published record, local names, etc., are discussed. In addition, critical notes by the authors and other specialists abound throughout the book. As a rule the so-called lower cryptogams are omitted from a local flora, but in the present instance the mosses, hepatics, and lichens are included. The algæ and fungi are alone wanting to complete the entire flora of the district. The amount of time and labour expended has obviously been a labour of love, and the result is one of the best, if not the best, of local floras extant. Fourteen full-page illustrations and a map of the district add considerably to the value of the book.

BIOLOGY.

First Course in Biology: Part I., Plant Biology, by L. H. Bailey; Parts II. and III.: Animal and Human Biology, by W. M. Coleman (New York: The Macmillan Company 1908; illustrated; 7s. 6d.).—One is somewhat led to wonder how there is room for the number of biological text-books which are now literally poured out from the press; but there seems to be an ocean ready to absorb all the streams, and the present one will therefore no doubt follow the usual course. The volume, which is for secondary education, seeks to develop a working training in the activities that connect the pupil with his own life; and from this standpoint seems to do all that can be desired. The one point we do not like is the separate paging of the three parts. The volume ought to have a large circulation both in this country and in America.

CHEMISTRY.

Foundations of Analytical Chemistry, by W. Ostwald, 3rd English Edition, translated from the 4th German Edition by George M'Gowan (London: Macmillan, 1908; pp. xxii. and 247, 6s. net).—In the past analytical chemistry has incurred, not altogether undeservedly, the reproach of being nothing more than the routine following of directions given in a practical text-book. With the increased education of the analyst, however, this state of things is gradually dying out, and analytical chemistry is slowly taking its true position in relation to theoretical chemistry. This is largely due to the work of such masters of the science as Professor Ostwald. In the present excellent elementary little work the theories of general chemistry are discussed with special reference to their bearing on analytical processes, and the developments of the theoretical science are extended to the practical details of laboratory work. Physical and chemical methods of separation are first discussed in five chapters, and these are followed by eight chapters dealing with the application of the general methods to particular elements. The work concludes with an appendix of suggested lecture experiments, but it lacks an index. Throughout, the argument can be readily followed by all who have a slight knowledge of general chemistry, and this clearness owes much to the excellence of Dr. M'Gowan's translation.

METEOROLOGY.

Water; Its Origin and Use, by W. Coles-Finch (London: Alston Rivers, Ltd., 1908; 504 pp.; 21s. net).—The author of this book is an engineer to an important waterworks, and so has been led to give some attention and study to the subject of the finding and distribution of water. In this volume he gives the notes and memoranda which he has accumulated during a number of years, in the hope that the readers may find in it some matter of interest and may be led to the contemplation of the wonders of Nature. He states that "the book does not pretend to be a scientific record; it is simply an ordinary person's interpretation of what he sees in Nature, and represents his best efforts to describe the same." The author has produced a very interesting book, full of information, and adorned with over 150 illustrations, most of which are of beautiful Alpine scenes, by Mrs. Aubrey Le Blond. The comprehensive way in which Mr. Coles-Finch deals with his subject may be gathered from the titles of the twenty chapters into which the book is divided, viz., Heat, Atmosphere, Clouds, Rain, Water, Forms of Water, etc., Snow, Ice, Glaciers, Springs, Rivers, Waterfalls, Lakes, Ocean and Sea, Mountains and Volcanoes, Chalk, Denudation, Water, how obtained, Use, Abuse, and Waste, Lessons from Nature. The following extract from the chapter on the "Atmosphere" will show that the book is written in a pleasant and readable style: "We will therefore devote a considerable portion of our story of water to trying to follow some of the methods by which the atmosphere fulfils these many duties, and acts as one of the principal of Nature's agents, raising, purifying, and supplying to the world pure water and air, two of the things most necessary to our existence, and on which two things the whole universe lives and grows, and without which all other necessaries of life could never exist."

NATURAL HISTORY.

Through Southern Mexico; being an Account of the Travels of a Naturalist, by Hans Gadow (London: Witherby and Co., 1908; pp. xxii. and 527, illustrated; 18s. net).—In this volume the author, who is well-known as an observant "all-round" naturalist, gives the results of his experiences during two periods of four months, each spent in wandering through some of the wilder parts of a most wonderful and intensely interesting country; and whether in describing the people and scenery, in discussing the local variation in colour of lizards and the warning-colours of coral-snakes, or in depicting the curious mushroom-beds grown by the leaf-cutting ants, he is equally at home, and equally fascinating. Dr. Gadow has in fact succeeded in producing one of the very best books of travel from the natural history point of view, that has come under our notice for many a day; and we strongly advise those of our readers who are interested in such matters to lose no time in procuring copies. Almost every kind of subject connected with the natural history of the country is touched upon more or less fully, and in such an attractive manner that each is teeming with interest. Very wonderful must have been the sight of gorgeously dressed macaws in their native haunts, which the author had the good fortune to behold. Whether these birds are stationary during the pine-cone season is doubtful; but it is certain that although they breed only in the tropical zone, their powers of flight are such that they can easily reach the temperate belt and return in the same day. Dr. Gadow is no respecter of long-established theories if he believes them wrong; and on this ground he runs atilt at the prevalent idea that the thorns of cactuses are for protective purposes. With this confessedly imperfect notice we must take leave of a charming and instructive volume.

ZOOLOGY.

Guide to the Specimens of the Horse Family Exhibited in the British Museum (London: Natural History Museum, 1907; pp. 42, illustrated; 1s.).—The increasing elaboration of the exhibition series in the natural history branch of the British Museum requires a corresponding augmentation in the number and style of the explanatory guide-books. The one before us is practically a condensed monograph of the horse family, admirable alike for its popular and yet clear and accurate style, and for the number and excellence of its illustrations. Domesticated as well as wild representatives of the group are included in the scope of these few pages; and the reader will learn all that is now known with regard to the relationship of the ordinary domesticated horses of Europe to their wild Central Asian cousin, and likewise the most probable theory of the origin of the Arab. The little volume should thus appeal to a very wide circle of readers, for while it will be in demand by the more intelligent visitors to the Museum as a guide to the collections, it should also attract the attention of all who take a scientific interest in the horse. In the latter respect it may be hoped that it will do something in the way of correcting a number of errors

which too frequently disfigure non-scientific works on "horsey" subjects; and, at all events, there will be no excuse for any such faults in the future. The sale of this latest addition to the Museum guide-books ought to be very large indeed. The only fault that we can find is that its low price and condensed information may tend to undersell non-subsidised publications.

Animal Life, by F. W. Gamble (London: Smith, Elder, and Co., 1908; pp. xviii. and 305; 6s. net).—In his preface, the author states that "the want of a small work dealing with the adaptations and factors of animal life in a broad and connected manner," is his excuse for writing the volume now before us. No excuse of any kind was needed, and Dr. Gamble is to be heartily congratulated on the production of a work full of interest, which we have read with the greatest pleasure from start to finish. Indeed, we have no hesitation in pronouncing this volume to be one of the very best and most satisfactory biological works that has come under our notice for many a day. Throughout, the author writes in an attractive and picturesque style, which cannot fail to carry the reader with him; while the absence of unnecessary technical terms and scientific names is a feature which might advantageously be copied in all works on popular science. To those of us who are more or less exclusively systematic naturalists many of the facts and theories recorded by Dr. Gamble will come almost as a revelation. How many of us, for instance, were acquainted with the manner in which a star-fish sets to work upon the unfortunate bivalve it has selected for its prey, or were aware of the intimate connection existing between the colouring matter of plants and that of our own blood? For every fact in the economy of Nature brought to the notice of his readers, the author seeks to find an adequate and satisfactory explanation; and for the most part such explanations seem, so far as we can judge, to meet their respective cases in the best possible manner. Of course, we can pick holes here and there; as, for instance, when it is stated that the sucking-fish is almost the only exception to the rule that animals are coloured dark above and light below; but these in no wise detract from the merits of the book as a whole. In these days of narrow specialism, every naturalist should read Dr. Gamble's work, if only to broaden his conception of Nature and Nature's contrivances and adaptations; while the volume may be not less warmly commended to the notice of the general reader.

MISCELLANEOUS.

Science in Modern Life, Vol. I., edited by J. R. Ainsworth Davis (London: The Gresham Publishing Co., 1908; 6s. net).—A literary and scientific publication of considerable interest makes its appearance with the first volume of "Science in Modern Life," which is intended to be a survey of scientific development, discovery and invention, and their relations to human progress and industry. The series is to be completed in six volumes, and in the first of them a survey of the latest discoveries and the present position of knowledge in astronomy, by Mr. A. C. D. Crommelin, occupies pride of place. Mr. Crommelin's well-known ability and recognised authority make his summarizing of the greatest value and instruction. Astronomy is followed very appropriately by geology, in which Mr. O. T. Jones, of H.M. Geological Survey, follows up the history of the universe by a survey of the history of that portion of it which is comprised in our own planet. Geology is to be followed in future volumes by Chemistry, Physics, General Biology, Zoology, Botany, Physiology and Medicine, Anthropology, and Engineering; and if the first volume, excellent alike in matter, treatment, and illustration is followed by others as good the complete work should be one of standard value for reference.

The Young Engineer, by Hammond Hall (London: Methuen, 1908; 5s. net).—We are quite certain that the boy of mechanical turn of mind into whose hands this book may fall will find that it contains just the sort of information that he wants. From tools to the finished engine, the instruction ranges. Nor is the matter restricted to one type only. Nearly every important variety is described with the aid of illustrations; steam, gas, and oil engines—stationary, locomotive, and marine; Lancashire boilers, Babcock and Willcox boilers; Serpollet boilers, and the modifications used on the White Steam Car. The story of the steam turbine is told from the form of Hero of Alexandria, two thousand years ago, to the engines of the *Mauretania* and *Lusitania*. All these things are described without unnecessary technicalities; yet this is no mere toy-book; the descriptions are accurate so far as they go. But they are told so as to stimulate the imagination as well as to instruct. What a picture the following calls up: "In a modern passenger steamship the condenser may consist of more than twenty miles of tubes, cooled by a flow of water amounting to 10,000 tons an hour"! Boys who have had some training with their hands will find the chapters on model making the most attractive. Altogether, the volume is a most desirable one. We consider it should be in every school library, and would be welcomed by most boys with whom we are acquainted.

Irrigation and Land Drainage, by W. Gibbons Cox, C.E.; 291 pages, Index, Illustrations and Map (London: The Australian Book Company; price 6s.).—This is a valuable and practical contribution to the important subject of the utilisation of artesian water in Australia, and is likely to be of immense use to those pioneers who are now opening up the central parts of this great continent by tapping important supplies of subterranean waters. Each of the great colonies is dealt with in turn, and every aspect of the subject receives consideration. The book is, indeed, a compendium of the subject. The geological notes are true, the author is an accomplished meteorologist, and he writes of the engineering difficulties as one familiar with the best means of overcoming them. His experience is of the widest nature, and what he has learned in Victoria, New South Wales, Queensland, and Western Australia, and what he has studied in Government reports, scientific papers, etc., he has here condensed into a valuable treatise. The illustrations from photographs show some of the spouting bores which have been sunk, and are a revelation to those who are accustomed to regard so much of the interior as hopelessly arid and barren. There is an intake area in New South Wales and Queensland of 68,000 square miles on which the mean annual rainfall is 25 inches. The author works out from this that 7,445½ millions of gallons of water percolate daily through the porous beds under these western plains. Of this only 546 millions of gallons are obtained from existing boreholes, and it is part of the author's object in writing this book to show the best means by which some of the remainder may be brought into use.

RUHSTRAT RHEOSTATS.—Messrs. Isenthal's new catalogue of rheostats includes a very large number of types, from simple rheostats to the high-tension rheostat, which is in use for the purpose of wireless telegraphy at the experimental radio-electric station at Gottingen. The total resistance of the last named rheostat is more than a million ohms; and at a pressure of 5,000 volts the regulation takes place in twenty-seven stops. Besides the rheostats, Messrs. Isenthal illustrate their new complete installations for electric furnaces, as well as their small motors and rotary converters for laboratory work.

LABORATORY APPARATUS.—A supplementary list of new apparatus for use in physical laboratory demonstrations, has just been published by Messrs. Newton, of Fleet Street; and among the items of it we may draw special attention to the new optical bench, and the projection apparatus which Mr. Cheshire, of the Birkbeck College, has designed for it. Among examples of apparatus, which though sometimes referred to as the playthings of science are valuable as illustrating important scientific facts, may be noted "Sympathetic Pendulums," Mr. S. L. Fletcher's "Sunset Experiment," and the Rev. H. V. Gill's "Earthquake Top." Mr. Duddell's "Singing Arc" is also now sold by Messrs. Newton.

XUM

MICROSCOPY

Conducted by F. SHILLINGTON SCALES, B.A., F.R.M.S.

The Preparation of Microscopical Objects.

(*Continued from page 292.*)

Both of the following alum stains are best used diluted, Delafield's say one in ten, and Erlich's about one in four, and with this strength about twenty minutes on an average will stain most sections satisfactorily.

Delafield's Hæmatoxylin.—This is a watery solution, and is made up as follows :—Dissolve 4 grams of hæmatoxylin crystals in 25 cc. of 95 per cent. alcohol. Add it to 400 cc. of a saturated aqueous solution of ammonia alum (say about 1 in 11 of water). Filter, and expose to both light and air for a week or more. Again filter, and then add 100 cc. of glycerine and 100 cc. of 95 per cent. alcohol (wood-spirit will do). Set the solution in the light and allow it to stay there until it becomes of a dark purplish colour, then re-filter and keep in a well-stoppered bottle. The solution keeps well and stains rapidly, but should not be used before at least a month has elapsed. It is used rather diluted, and is then more precise. As a watery stain it tends to swell mucus, which it stains well. The water must, of course, be carefully removed by slightly alkaline graduated alcoholic baths before mounting in Canada balsam.

Erlich's Acid Hæmatoxylin.—

Water	50 cc.
Absolute alcohol	50 cc.
Glycerine	50 cc.
Glacial acetic acid	5 cc.
Hæmatoxylin	1 gram.
Alum in excess.	

Put this solution into a bottle with a cotton-wool plug only, and allow it to stand in the light for about a month, until it has ripened to a dark claret colour. Then stopper the bottle. It stains rapidly and keeps for years if kept well stoppered. There is little tendency to over-staining. It is a great favourite for nuclear work, owing to its sharp differentiation of chromatin. The acetic acid is added to prevent precipitation and to enable the stain to differentiate more sharply.

Iron Hæmatoxylin.—This is a rapid and permanent stain, which is of wide and almost universal application. As Mr. Lee points out, it has a certain optical quality which is peculiarly suited to the employment of high powers. It is also of service for thin sections.

Two solutions are required :—

I.—Ferric alum	2·5 grams.
Distilled water	100 cc.
II.—Hæmatoxylin	·5 gram.
Distilled water	100 cc.

These are not to be mixed, but are to be used separately. The hæmatoxylin solution must ripen as before explained. All alcohol must be removed from the sections, which are then stained for from three to six hours or more in Solution I., rinsed for five minutes in water, then stained for twelve to thirty-six hours in Solution II., again rinsed with water, and returned to Solution I. for about 10 to 30 minutes, which differentiates the stain. The process should be watched under the microscope, but a change to a dull grey colour is generally a good guide. The sections are finally washed for about an hour in tap water. It is important that all the iron-alum should be washed out, or the sections will fade later on. If any iron-alum is left in the sections before transference to Solution II. it will turn the hæmatoxylin black; but this does not matter. The fine differentiation of cell structure may require twelve or more hours in both solutions. The clearing must be done with xylol, and the mounting in xylol or benzole balsam. I have mentioned this stain because it is the best of the hæmatoxylin stains, and is well worth trouble in mastering.

(*To be continued.*)

Royal Microscopical Society.

November 18.—Conrad Beck, Esq., Vice-President, in the chair. The Secretary announced the new arrangements which had been made for holding sectional meetings, under which any ten or more Fellows might combine, if interested in a particular subject, to form a section to pursue its special study. At present three such sections were to be formed, one for the study of Medical Bacteriology, another for Biology other than Medical Biology, and a third for the Microscope itself and its adjuncts. These sections meet at the Society's rooms in Hanover Square on the first, second, and fourth Wednesdays in each month. That for Medical Biology will be under the direction of Dr. Eyre, and that for Pond Life under Mr. Scourfield. Mr. J. I. Pigg exhibited and described two specimens of the Coccids (*Lecanium hemisphæricum*), one of which was a living gravid female, the other was a dead female after parturition, the chitine shell containing the usual large number of eggs characteristic of the species. Mr. C. F. Rousselet described a number of mounted specimens of pond life, shown under microscopes in the room. These were Infusoria, *Hydra*, *Volvox* with yellow stellate oospheres from Germany, apparently exceedingly rare in this country, and some fresh-water Medusæ, and their Hydroid stage, *i.e.*, *Limnocodium Lowerbyi* from the Royal Botanic Gardens, Regent's Park (collected about 1890, since disappeared); *Mœrisia Lyonsi* from Lake Qurun in Egypt, and an undescribed Medusa lately received by him from Rhodesia. Stress was laid on the large field for enquiry offered by the Infusoria and the inadequacy of our present knowledge on the subject. Mr. A. A. C. E. Merlin contributed a paper on "A New-Growing Cell for Critical Observations Under the Highest Powers," designed for the examination of Bacteria, Rhizopods, and flagellate Infusoria. Professor J. A. Thomson contributed a paper on "Studeria," a remarkable new genus of Alcyonarians, illustrated by three diagrams, and a specimen shown under the microscope. Dr. Marshall D. Ewell contributed a paper on "The Present Status of Micrometry," giving values for the measurements of many micrometers in common use, and tabulating their divergencies. The paper led to an interesting discussion, during which the suggestion was made that the Society should take steps to provide itself with a standardised stage micrometer.

Quekett Microscopical Club.

December 4.—A new growing cell for use with the highest powers, designed by Mr. A. A. C. Eliot Merlin, F.R.M.S., was exhibited by Messrs. Baker.

Mr. D. J. Scourfield, F.R.M.S., delivered a lecture, with lantern illustrations, on "The Locomotion of Microscopic Aquatic Organisms." The majority of such organisms in the main are made up of tissues

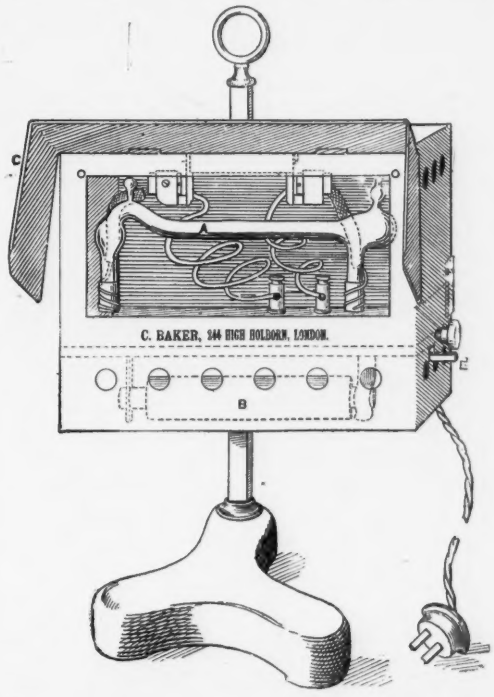
having a specific gravity very little more than that of water, and, consequently, the medium in which they are immersed affords them very considerable support. The most delicate and fragile of all known organisms are found in water. The simplest mode of progression is that found in *Amœba*. The second type is produced by the action of flagella, and the third is effected by cilia. More specialised methods were described, and included medusoid motion, the methods adopted by nematodes, and that common to *Salpa*, and, finally, the highest method of locomotion—that due to appendages actuated by muscles—in more complex forms. It was stated that in its main features amœboid motion was essentially a physical phenomenon depending chiefly upon changes in the surface-tension of the naked protoplasm. A flagellum was defined as a permanent, motile, whip-like extension of the living protoplasm capable of moving the whole organism to which it belongs. It is considered that the motive power of a flagellum resides in the flagellum itself. A cilium is, like a flagellum, a permanent, motile, whip-like extension of the living cell-substance, but, unlike the flagellum, is incapable of moving the body to which it is attached by its own individual efforts. It is always associated with a number of other cilia, with which it acts in harmony.

The President referred to the rapid amœboid movements exhibited by certain star-shaped and other cells found in the body-cavity of the sea-urchin.

Mercury Vapour Lamp.

A means of illumination of the microscope which is entirely satisfactory from all points of view remains yet to be devised. For ordinary work by artificial light there is nothing to beat the ordinary half-inch paraffin lamp, standing low upon the table, and made adjustable in height. The edge of the flame gives an edge which can be focussed, and the yellow nature of the rays can be removed by the interposition of blue glass of varying shades. If mono-chromatic light be required, a Gifford screen can be interposed, but, unfortunately, it is here that the lamp begins to fail, for though it passes ample light for a $\frac{1}{12}$ inch immersion (if the condenser be properly adjusted) without the screen, its rays are insufficient to give satisfactory illumination with the screen. The incandescent gas burner is a most unsatisfactory illuminant—too strong, too diffuse, and hampered by the image of the mantle in the object; the incandescent electric lamp is worse, but the Nernst lamp is much better. Unfortunately its fine filaments also form a troublesome image, whilst the uncertainty of the life of the filaments is a considerable drawback. The use of the arc-lamp or of the Heliostat is, naturally, of a restricted kind. Mr. J. E. Barnard, F.R.M.S., has recently elaborated an entirely different source of illumination which has several interesting points. When a current of electricity is passed through an exhausted glass tube partly filled with mercury, the vapour of the mercury becomes highly luminous. The quality of the light thus emitted is important, as it is confined to a few wave-lengths of the spectrum, and these, moreover, are widely separated, corresponding to narrow bands in the orange, in the yellow-green, in the green, in the blue, and in the violet. It will be observed that the red rays are absent, so that the light is more efficient than ordinary forms of illumination, but by the aid of suitable screens monochromatic light in several regions of the spectrum can readily be obtained, thus affording good contrast with sections stained with different stains.

The accompanying illustration shows the mercury vapour lamp as designed by Mr. Barnard and made by Mr. C. Baker, of High Holborn. It will be observed to take the form of an adjustable metal box supported upon an upright stand, and containing a horizontal mercury tube, marked A in the drawing, and a resistance, marked B. The lamp is started by pressing up lever E, which cuts out a portion of the resistance, and at the same time depressing the left end of the box, so that the mercury flows into that portion of the tube. On slowly bringing the tube horizontal again, and still



keeping the lever pressed up, an arc will be formed which will extend along the tube as the mercury retreats to the lower reservoir. This procedure may need to be repeated two or three times before the lever can be released. The box measures 6½ ins. by 3 ins. by 3 ins., and the lamp can be supplied for any voltage from 80 to 250. Screens and carrier can be supplied with the lamp. The apparatus was recently exhibited before the Royal Microscopical Society, where it attracted considerable attention.

Notes and Queries.

Microscopical Objects.—Mr. R. J. Mason, of Clapham Park Road, S.W., has sent me for inspection some beautiful slides of selected and arranged diatoms from the New Hebrides and elsewhere, which are sold at very moderate prices, varying from 1s. 6d. to 3s. 6d. each, according to the work in the slide. He has also sent me specimens of his well-known Student's Botanical Series, which are supplied ready cut, stained, and cleared in clove oil, or some similar medium, and merely require mounting. As these specimens can be purchased for 1s. 6d. per half-dozen, it forms an inexpensive way of adding some really good botanical slides to one's collection. There are many other series of unmounted objects, such as ferns, starches, horn and hoof sections, feathers, insect parts, etc., which can be obtained at 1s. 1d. per set of 6 or 12, as the case may be. Mr. Mason makes a speciality of these unmounted objects and of all materials for mounting.

[*Communications and inquiries on Microscopical matters should be addressed to F. Shillington Scales, "Jersey," St. Barnabas Road, Cambridge. Correspondents are requested not to send specimens to be named.*]

XUM

The Face of the Sky for January.

By W. SHACKLETON, F.R.A.S.

THE SUN.—On the 1st the Sun rises at 8.8 and sets at 3.59; on the 31st he rises at 7.43 and sets at 4.45. The earth is nearest the Sun on the 3rd, when the Sun attains his maximum apparent diameter of 32′ 35″. Sun-spots are not very numerous, though an occasional group may be observed on the solar disc. The positions of the Sun's axis, centre of the disc, and heliographic longitude are given below:—

Date.	Axis inclined from N. point.	Centre of Disc S. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
Jan. 1 ..	2° 1′E	3° 10′	209° 6
,, 11 ..	2° 50′W	4° 16′	77° 9
,, 21 ..	7° 31′W	5° 14′	306° 3
,, 31 ..	11° 52′W	6° 2′	174° 6

THE MOON:—

Date.	Phases.	H. M.
Jan. 6 ..	○ Full Moon	2 13 p.m.
,, 14 ..	☾ Last Quarter	6 11 p.m.
,, 22 ..	● New Moon	0 12 a.m.
,, 28 ..	☽ First Quarter	3 7 p.m.
Jan. 11 ..	Apogee	2 54 p.m.
,, 23 ..	Perigee	1 12 p.m.

OCCULTATIONS.—The following are the principal occultations visible from Greenwich before midnight:—

Date.	Star's Name.	Magnitude.	Disappearance.		Reappearance.		Moon's Age.
			Mean Time.	Angle from N. point.	Mean Time.	Angle from N. point.	
			p. m.		p. m.		d. h.
Jan. 25	30 Piscium ..	4·7	5 59	51°	7 2	248°	3 18
,, 25	33 Piscium ..	4·6	7 44	86°	8 37	219°	3 20
,, 31	n Tauri ..	5·2	5 1	52°	6 7	274°	9 17

THE PLANETS.—Mercury (Jan. 1, R.A. 19h 8m; Dec. S. 24° 35′. Jan. 31, R.A. 22h 0m; Dec. S. 10° 56′) is an evening star in Sagittarius and Capricorn. On the 27th the planet is at greatest Easterly elongation of 18° 25′, when he sets about 6.20 p.m.

Venus (Jan. 1, R.A. 16h 43m; Dec. S. 21° 2′. Jan. 31, R.A. 19h 24m; Dec. S. 22° 9′) is a morning star in Ophiuchus and Sagittarius. In the telescope the planet appears gibbous, 0·9 of the disc being illuminated, with an apparent diameter of 11″. On account of the great Southerly declination the planet is not well placed for observation. She rises about 6.25 a.m. on the 15th.

Mars (Jan. 1, R.A. 15h 28m; Dec. S. 18° 22′. Jan. 31, R.A. 16h 52m; Dec. S. 22° 21′) is a morning star in Scorpio rising about 4 a.m. The planet appears as a rather faint star, and for all practical purposes of observation is out of range.

Jupiter (Jan. 1, R.A. 11h 5m; Dec. N. 7° 12′. Jan. 31, R.A. 10h 59m; Dec. N. 7° 55′) rises about 8.40 p.m. on the 15th and is a brilliant object in the evening sky looking East. The planet is describing a retrograde path in Leo. The attendant bright moons can be seen in very small telescopes, or even in a pair of binoculars magnifying 6 or 8 times, whilst the belts are also visible in small telescopes of about two inches aperture using a magnifying power of about 50. The equatorial diameter of the planet on the 16th is 41″·5, and the polar diameter is 2″·7 smaller; this polar flattening is readily observed in telescopes powerful enough to see the belts.

The following table gives the satellite phenomena visible up to midnight:—

Date.	Satellite.	Phenomenon.	P.M.'s H. M.	Date.	Satellite.	Phenomenon.	P.M.'s H. M.	Date.	Satellite.	Phenomenon.	P.M.'s H. M.
Jan.				Jan				Jan.			
5	II.	Ec. D.	11 11	14	II.	Tr. I.	10 8	21	I.	Oc. R.	11 9
6	I.	Tr. E.	10 23		II.	Sh. E.	11 7	22	IV.	Tr. I.	9 41
7	II.	Tr. E.	10 36	18	III.	Oc R.	9 55	23	II.	Oc. R.	10 9
12	I.	Ec. D.	11 41	20	I.	Sh. I.	10 48	28	I.	Ec. D.	9 55
13	I.	Tr. I.	9 53		I.	Tr. I.	11 40	29	I.	Sh. E.	9 30
	I.	Sh. E.	11 14	21	II.	Sh. I.	10 48		I.	Tr. E.	10 11

"Oc. D." denotes the disappearance of the Satellite behind the disc, and "Oc. R." its reappearance; "Tr. I." the ingress of a transit across the disc, and "Tr. E." its egress; "Sh. I." the ingress of a transit of the shadow across the disc, and "Sh. E." its egress; "Ec. D." denotes disappearance of Satellite by Eclipse, and "Ec. R." its reappearance.

Saturn (Jan. 1, R.A. 0h 18m; Dec. S. 0° 38′. Jan. 31, R.A. 0h 26m; Dec. S. 0° 16′) is a conspicuous object in the evening sky, being due South at 5.35 p.m. on the 1st and at 3.45 p.m. on the 31st. The planet is situated in Pisces and appears in the sky a few degrees South-East of the square of Pegasus. As seen in the telescope the ring appears slightly open, since we are looking on the Southern surface at an angle of 5°. The apparent diameters of the outer major and minor axes of the ring are respectively 40″ and 3″·8, whilst the diameter of the ball is 16″. In small telescopes the dusky belt-like markings on the ball, although not so conspicuous as those on Jupiter, may also readily be discerned.

Uranus (Jan. 16, R.A. 9h 16m; Dec. S. 22° 42′) is in conjunction with the Sun on the 7th, and hence is unobservable.

Neptune (Jan. 16, R.A. 7h 7m; Dec. N. 21° 47′) is in opposition to the Sun on the 6th, and hence about this date is on the meridian at midnight. The planet is situated in Gemini, about half a degree South of the star δ Geminorum, but he is difficult to identify except in large telescopes. He may, however, be detected by his relative motion if successive observations are made at intervals of some days.

METEOR SHOWERS:—

Date.	Radiant.		Name.
	R.A.	Dec.	
	h. m.		
Jan. 2-3 ..	XV. 20	+53°	Quadrantids.
,, 17 ..	XIX. 40	+53°	θ Cygnids.

Minima of Algol occur on the 3rd at 7.32 p.m., the 23rd at 9.15 p.m., and the 26th at 6.4 p.m.

TELESCOPIC OBJECTS:—

Nebulæ.—Orion Nebula, situated in the sword of Orion, and surrounding the multiple star θ, is the finest of all nebulæ; with a 3 or 4 inch telescope it is best observed when low powers are employed.

Crab Nebula (M 1), in Taurus, situated about 1½° North-West of ζ Tauri, in R.A. 5h 23m, Dec. 21° 58′ N.

Cluster.—M 37, situated in Auriga, is one of the finest clusters, and very compact; its position is R.A. 5h 46m, Dec. 32° 32′ N.

Double Stars.—β Orionis (Rigel), mags. 1 and 9, separation 9″. On account of the brightness of the principal star, this double is a fair test for a good object-glass of about 3-inch aperture.

δ Orionis, mags. 2 and 7, separation 53″; easy double.

ζ Orionis, triple, mags. 3, 6, and 10, separation 2″·5 and 56″; rather difficult in a 3-inch telescope.

λ Orionis, mags. 4 and 6, separation 4″·5; pretty double.

σ Orionis, triple, mags. 4, 8, and 7, separation 12·5″ and 42′.